United States Army Aviation Logistics School
Fort Eustis, Virginia

APRIL, 1994

THIS DOCUMENT HAS BEEN REVIEWED FOR OPSEC CONSIDERATIONS

STUDENT HANDOUT

ELECTRICAL SYSTEMS

071-610-10

The proponent for this SH is USAALS

INTRODUCTION

TERMINAL LEARNING OBJECTIVE:

At the completion of this lesson you will:

ACTION: Analyze electrical systems malfunctions and prescribe corrective action (s) for the abnormal conditions.

CONDITIONS: Given an AH-64A helicopter, applicable technical manuals, and a requirement to analyze electrical systems malfunctions.

STANDARDS: Analyze malfunctions of the AH-64A electrical systems, in accordance with the TM 1-1520-238-T series manuals, TM 55-1520-238-CL, TM 55-1520-238-MTF, TM 55-1520-238-10 and TM 55-1520-238-23 series technical manuals.

SAFETY REQUIREMENTS: In addition to specific safety requirements of this lesson plan, aviation shop and flight line safety standards established in the technical manuals will be reinforced.

RISK ASSESSMENT LEVEL: Caution

WARNING

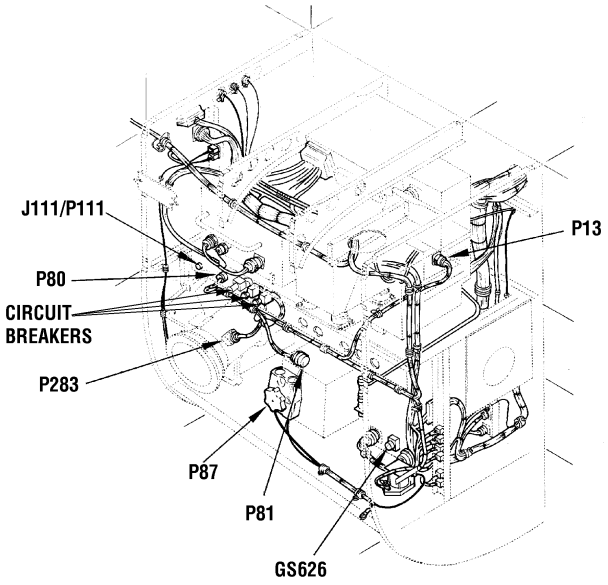
ELECTRICAL POWER

Electrical power operating or maintenance procedures, practices or conditions, which, if not strictly observed, could result in injury or death to personnel. These WARNINGS must be strictly obeyed by all personnel.

ENVIRONMENTAL CONSIDERATIONS: None

EVALUATION: This lesson will be evaluated during 9C7-505-04, Practical Written Evaluation and 9C7-200-08, End-of-Course Comprehensive Test Flight Evaluation.

TYPICAL WIRING HARNESS AND CIRCUIT PROTECTION



NOTES

A. AH-64A Wiring and Circuit Protection

1. Wiring system

a. Distributes AC and DC electrical power and to interconnect the electrical and electronic systems located throughout the AH-64A helicopter.

b. The wiring system consists of high density wiring harnesses that are fabricated from appropriate types of wiring, termination devices and electrical connectors. The harnesses are routed throughout the airframe in a manner that enhances the combat survivability of the crewmembers and the helicopter.

2. Circuit protection system

a. Provides thermal protection for the AH-64A electrical and electronic systems in case of equipment failure or battle damage. The protection includes the AC and DC electrical power sources, and the equipment that is supplied power.

b. Circuit protection system description

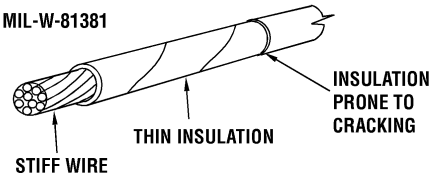
(1) Thermally operated, manually resetable circuit breakers. They are mounted on circuit breaker panels in the pilot crewstation, CPG crewstation, aft equipment bay, and the aft avionics bay. The individual circuit breakers are labeled as to the system they protect and the maximum current value at which they will stay connected at ambient temperature. At 200% rated value, they will trip within 4 to 20 seconds.

(2) Thermally operated, electrically resetable, Remote Control Circuit Breakers (RCCB's) are mounted in the electrical power center and the left and right wings.

(3) Thermally opened, replaceable current limiters are mounted in the electrical power center.

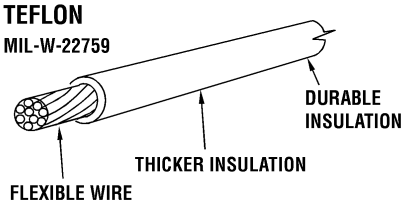
WIRING INSULATION TYPES

KAPTON
MIL-W-81381



AH-64A SERIAL NUMBERS 82-23355 thru 86-8950

TEFLON
MIL-W-22759



AH-64A SERIAL NUMBERS SUBSEQUENT TO 86-8950

00-94-02

NOTES

B. Wiring on the AH-64A helicopter is categorized by insulation type, wire type, conductor arrangement, and wire gauge. Wire markings are used to identify the wiring for maintenance purposes.

1. Insulation

a. Insulation is used to isolate the electrical current carrying conductors from each other and from the airframe (ground) to prevent short circuit conditions.

b. Insulation is also used to prevent damage to the conductors from fluids encountered during helicopter operation and from environmental sources.

c. Insulation types

(1) Kapton insulated wiring, MIL-W-81381, is used on AH-64A helicopters Serial Number 82-23355 through Serial Number 86-8950.

(a) Yellow colored insulation.

(b) Thinner insulation saving space and weight.

(c) Enhanced combat survivability due to high tolerance to heat and resistance to abrasion.

(d) Undesirable characteristics of Kapton wire noted in service

1) Insulation cracking.

2) Outer jacket deterioration.

3) Wire was stiff and difficult to route in the helicopter and subject to fatigue failures.

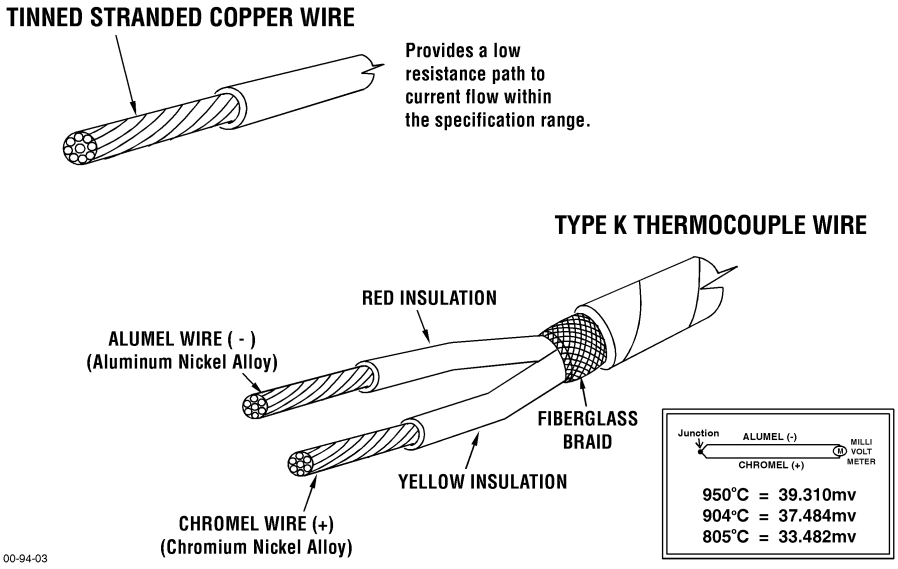
4) The thin Kapton insulation did not allow for a tight fit in the environmental seal of circular MIL connectors. This allowed contamination and corrosion of electrical connections due to moisture and chemical incursion.

(2) Teflon insulated wiring, MIL-W-22759, is used on AH-64A helicopters Serial Number 86-8950 and subsequent.

(a) White colored insulation.

(b) Teflon insulated wiring largely corrected the problems associated with the use of Kapton wire.

WIRING CONDUCTOR TYPES



NOTES

2. Conductors

a. Conductors are used to provide circuit paths, through which electron current flow is used to provide supply voltages, signals, and control functions necessary for AH-64A electrical and electronic equipment operation

b. The conductor types are determined by the application.

(1) Tinned, stranded copper wire is used for virtually all the AH-64A wiring. Copper wire provides a low resistance to current flow within the current range and temperature specification for a given size (gauge) wire.

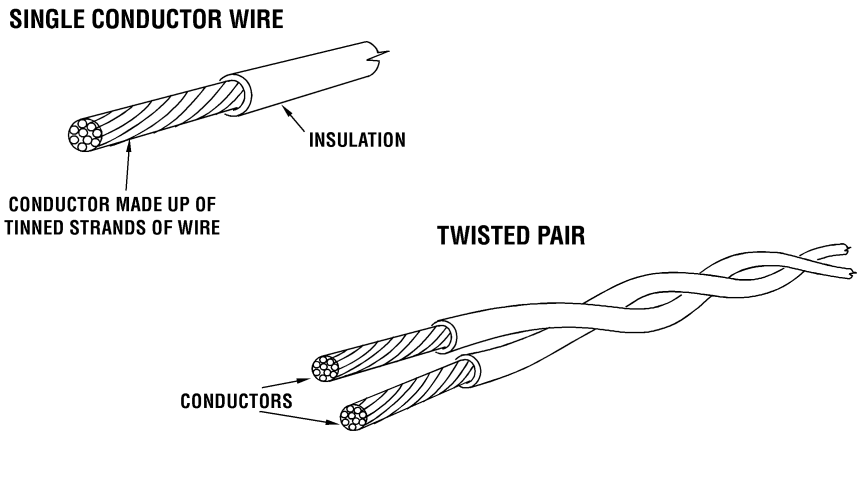
(2) Alumel/Chromel is used for the AH-64A powerplants TGT wiring and APU EGT thermocouple wiring. The wires are arranged as an insulated pair, covered with a braided fiberglass cover. A layer of insulation covers the whole assembly. The insulation for thermocouple wiring is capable of withstanding high temperatures.

(a) The Alumel/Chromel wires, when permanently joined at one end, creates a thermocouple junction. The junction provides a milli-volt source that will change predictably with temperature.

(b) Electrical or electronic devices convert this milli-volt temperature signal to a visual indication of temperature for interpretation by the crewmembers.

(c) Because the junction creates a voltage, the proper terminals, lugs, pins, sockets, and wiring must be used throughout. Any incorrect component used in the system will cause an error. The incorrect component becomes another junction and affects the milli-volt signal established by the real junction. This results in an incorrect temperature being displayed to the crewmembers.

CONDUCTOR CONFIGURATIONS I



NOTES

3. Conductor configurations

a. Single conductor wire and cable (a cable is usually a large diameter wire)

(1) Single conductor wire is composed of individual tinned strands of wire, twisted together during the manufacturing process under closely controlled conditions.

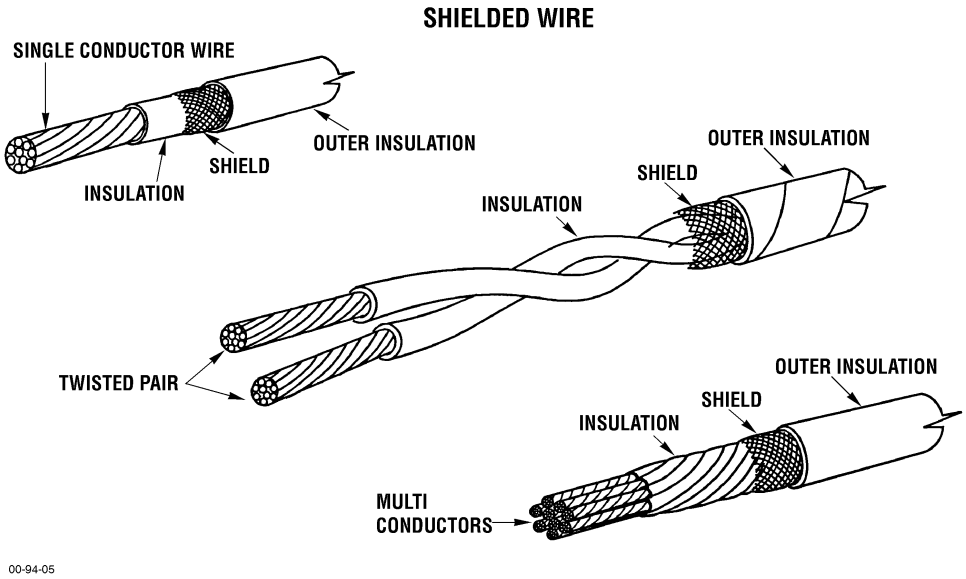
(2) The conductor is covered with an insulating coating that meets the specifications for which the wire is intended.

b. Twisted-pair

(1) Twisted-pair consists of two insulated single conductor wires, twisted together at a controlled number of twists per foot. Twisted-pair is normally utilized for an electronic signal and the return path for that same signal. The twist in the wiring prevents it from laying exactly next to the wiring of another circuit. This reduces the undesirable cross-coupling of one signal into another by transformer action.

(2) Multiconductor wire is constructed in the same manner as twisted pair wiring. It also minimizes cross-coupling. Twisting of the wire also keeps the harness together.

CONDUCTOR CONFIGURATIONS II



NOTES

c. Shielded

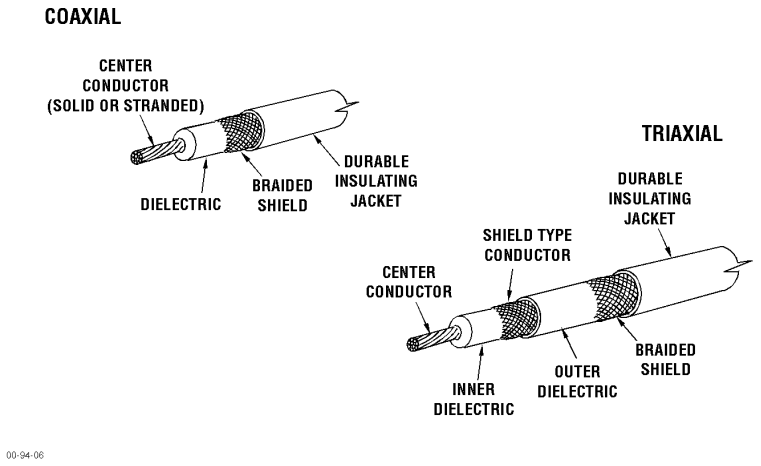
(1) Single conductor shielded wire is composed of a single conductor wire, with the addition of a braided shield and insulation to cover it. The addition of the shield provides further protection from cross coupling of undesirable signals. This is accomplished by providing a circuit for the undesirable signal to reach airframe ground or some other ground, as required. The shield may be connected to ground at one or both ends, as requirements dictate.

(2) Shielded pair is made the same as the twisted pair, with the addition of a braided shield and insulation to cover it. The advantages of shielding are the same as for single conductor shielded wire.

(3) Multiconductor shielded wire is the same as the multiconductor wire and has the advantages of shielding.

(4) The integrity of the shield and its connections are critical for some systems, especially the flight control and communications systems. The shielding inhibits cross-coupling of electronic signals and aids in preventing the inadvertent operation of helicopter systems.

CONDUCTOR CONFIGURATIONS III



NOTES

d. Coaxial

(1) Coaxial cables consist of a stranded (or a one piece solid wire) center conductor, an insulator (called a dielectric), a braided shield, and a durable insulating jacket. All of the coaxial cable components are manufactured to rigid specifications.

(2) Coaxial cables are used to conduct radio-frequency energy. Radio frequency (RF) energy is very sensitive to physical dimensions. If the dimensions of a coax are altered by flattening, smashing, kinking, or a sharp bend; the RF energy may be reduced or lost entirely.

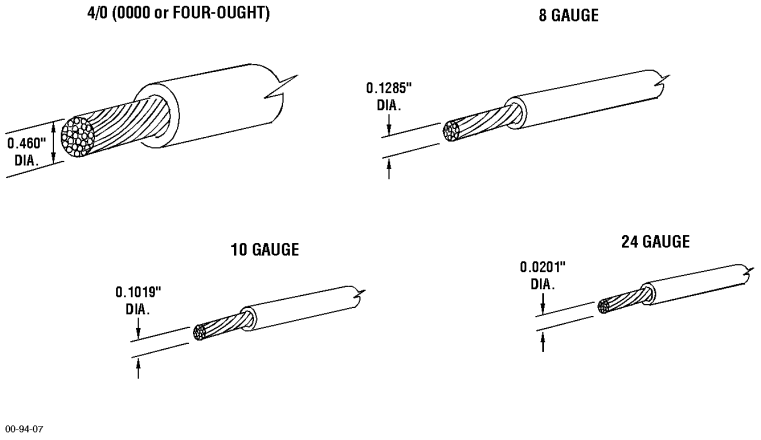
(3) Special low-loss coaxial cables are used for microwave transmission and reception work in the AN/ALQ-144 radar jammer, the AN/APR-39 radar warning set, and the AN/APX-100 identification friend or foe systems. These special low-loss coaxial cables usually employ a one piece, solid wire for the center conductor.

e. Triaxial

(1) Triaxial cables consist of a stranded (or a one piece solid wire) center conductor, an inner insulator (called a dielectric), a shield type conductor, an outer dielectric, a braided shield, and a durable insulating jacket. All of the triaxial cable components are manufactured to rigid specifications.

(2) Triaxial cables are used to conduct radio-frequency energy where isolation from outside interference is critical Radio frequency (RF) energy is very sensitive to physical dimensions. If the dimensions of the triax are altered, the RF energy may be reduced or lost entirely. The AH-64A video system uses triaxial cable between symbol generator and other video system components.

WIRE GAUGES



NOTES

4. Wire gauges

a. The gauge, a standardized measurement of wire, is the main factor of how much current a wire can safely carry.

(1) Large copper wires (usually called cables) are used for high current applications in power generation and distribution.

(a) Gauge 0000 (4/0, pronounced "four-ought") through 8.

(b) Small gauge numbers indicate large diameter wire and high current capability. 4/0 is the smallest gauge number and indicates the largest diameter wiring.

(c) Generators, transformer rectifiers, contactors, and busing all generally use large gauge interconnect wiring.

(2) Small copper wires are used for low current applications to electrical and electronic systems.

(a) Gauge 24-10

(b) Large gauge numbers indicates small diameter wire and low current capability. 24 is the largest gauge number and indicates the smallest diameter wiring

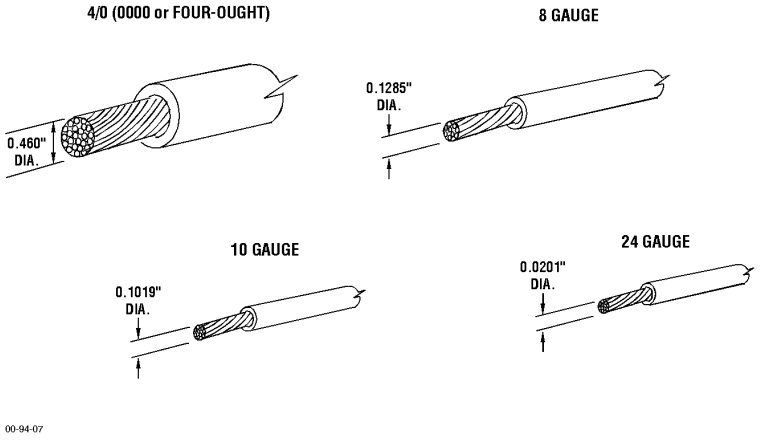
(c) Control, switching, lighting, and power to LRU's all generally use small gauge interconnect wiring.

(d) Multiplex uses special low capacitance, twisted pair, shielded wiring.

(e) Communication/Navigation systems use small gauge wiring, special purpose Tempest wiring, coaxial, and triaxial wiring.

b. MIL-W-5088E specifies current carrying capacity of commonly used wire sizes. Other requirements may specify wire gauges and current requirements other than listed in the table.

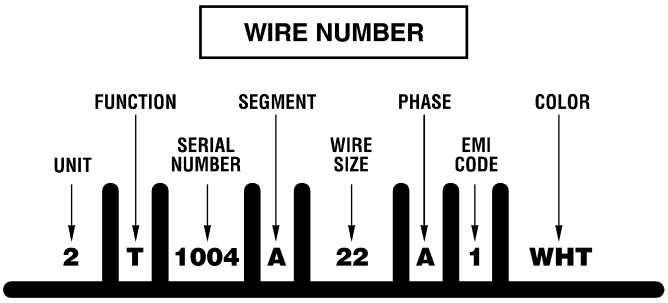
WIRE GAUGES



NOTES

Copper Wire Size (AWG)	Wire Diameter in inches	DC resistance in OHM's per 1000 ft, at 20E C	Continuous-duty Current in Amps (Wires in conduit or bundles)
24	0.0201	26.7	2
22	0.0253	16.9	5
20	0.320	10.5	7.5
18	0.403	6.64	10
16	0.508	4.18	13
14	0.641	2.63	17
12	0.0808	1.65	23
10	0.1019	1.039	33
8	0.1285	0.6532	46
6	0.1620	0.4110	60
4	0.2043	0.2584	80
2	0.2576	0.1625	100
1	0.2893	0.1289	125
0 (1/0 or ought)	0.3249	0.1022	150
00 (2/0 or double-ought)	0.3648	0.0821	175
000 (3/0 or triple-ought)	0.4096	0.06362	200
0000 (4/0 or four-ought)	0.4600	0.05045	225

WIRE MARKING I



This wire is from wire harness 605. It connects the MISSION IHADSS, CB41 Phase "A", to the electrical power center P1, terminal 11.

00-94-08

NOTES

5. Wire marking

a. Each wire is marked periodically down its entire length with a unique wire number. Each wire number is different and consists of a group of numbers and letters so the wire can be identified during maintenance actions. The wire number is broken down into specific elements that provide information about a wire.

(1) Unit - if applicable (number one engine, number two VHF, etc.)

(2) Function - identifies the system.

(3) Serial number - differentiates between wires in a circuit (power, ground, control for an LRU, or other electrical component).

(4) Segment Letter - differentiates segments of wire between wires in the same circuit (circuit breaker to connector, connector to LRU).

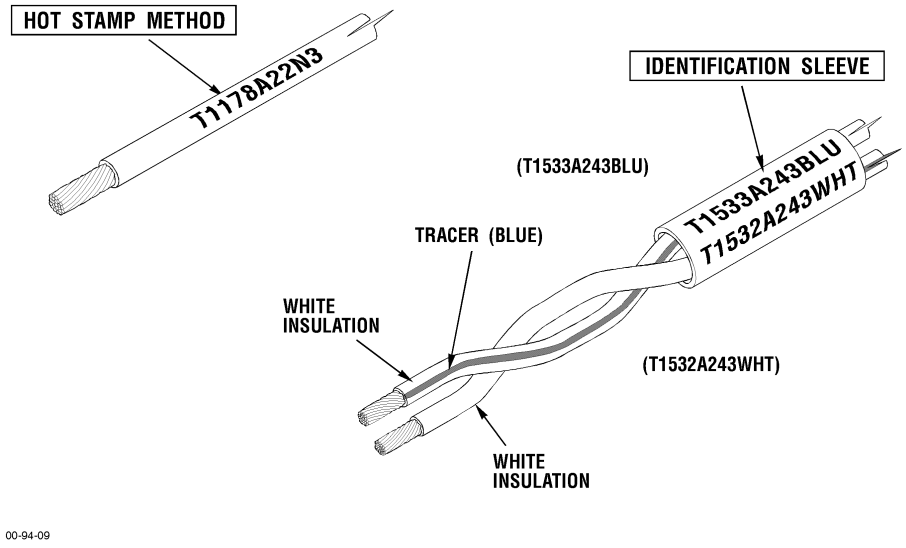
(5) Wire Size - is used to identify the gauge of the wire.

(6) Phase letter - is used to identify the wire as to phase, ground, or thermocouple application, if they apply.

(7) EMI category - identifies the susceptibility of a circuit to EMI interference.

(8) Color - identifies the colored tracer on a wire, if applicable. This is usually reserved for the individual wires within twisted pair, multiconductor, shielded, or unshielded wires and cables.

WIRE MARKING II



NOTES

b. Two methods are generally used to affix wire numbers to wiring, the hot stamp method and identification sleeves.

(1) The hot stamp method applies the wire number directly to the wire insulation. Most single conductor wires and cables are marked by the hot stamp method.

(2) Identification sleeve are used in applications where the wire or cable cannot be hot stamped with the wire number. The identification sleeves are hot stamped or marked with permanent ink before installation on a wire or cable.

(a) Types of wiring that use identification sleeves

1) Twisted-pair

2) Multiconductor wire

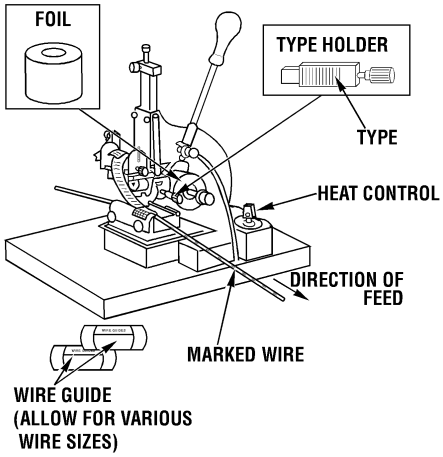
3) Shielded wire

4) Thermocouple wiring

5) Coaxial or triaxial cables (stamping would deform the precision aspects of the cable)

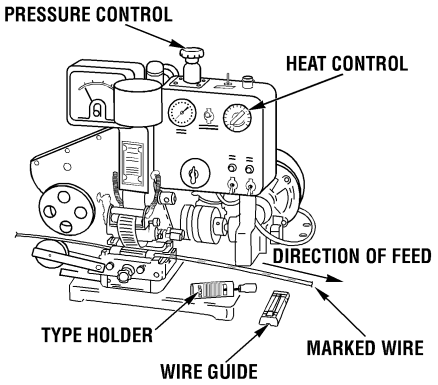
WIRE MARKING MACHINES

HAND OPERATED WIRE MARKING MACHINE



00-94-10

AUTOMATIC WIRE MARKING MACHINE



NOTES

(3) There are two basic wire marking machines, hand operated and automatic.

(a) Wire marking machine basic components

1) The type holder

2) Wire guide

3) Marking foil

(b) Simplified operation

1) The type and it's holder is held in alignment and heated by the marking machine. The temperature is preset by the operator.

2) The marking foil is held in alignment by the marking machine (the foil is advanced automatically, for both types of machines, each time a wire number is stamped on the wire insulation).

3) The wire is held precisely by a wire guide and is advanced through the guide a specified distance each time the wire is stamped.

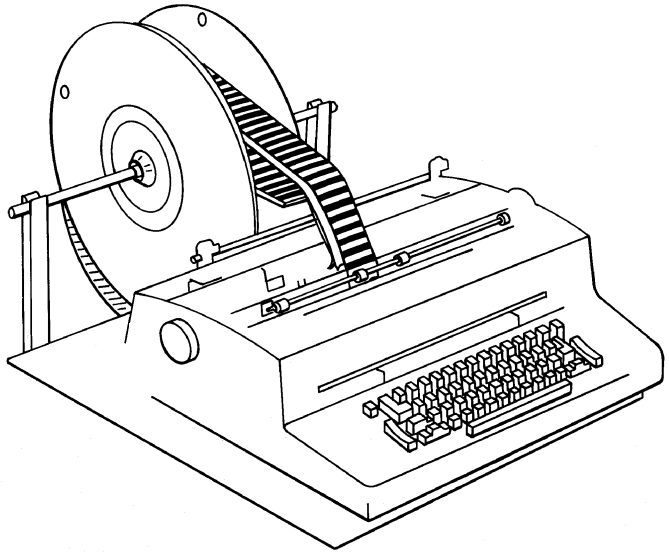
a) The operator must advance the desired length of wire through the guide manually, when using a hand operated wire marking machine.

b) An automatic wire marking machine will stamp a length of wire at lengths preset by the operator.

4) The foil is stamped against the wire with the heated type by both types of machines.

5) Special wire guides for both types of machines allow the stamping of identification sleeves instead of wire.

TMS PLATEN AND DEFLECTOR



83-2854A

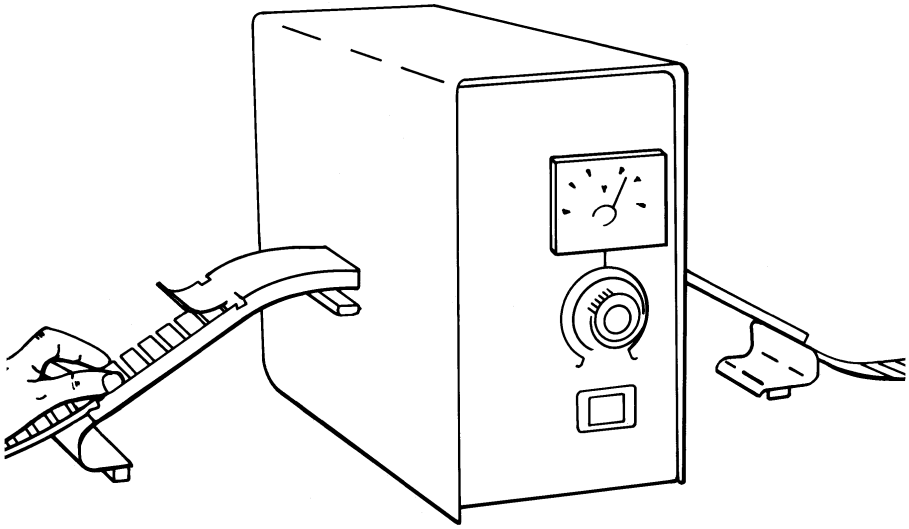
NOTES

(c) Special tools are used to mark and install the identification sleeves during the manufacturing process.

1) Marking tools

a) TMS platen and deflector is used to mark the wire number on the sleeves.

TMS-208 PERMATIZER



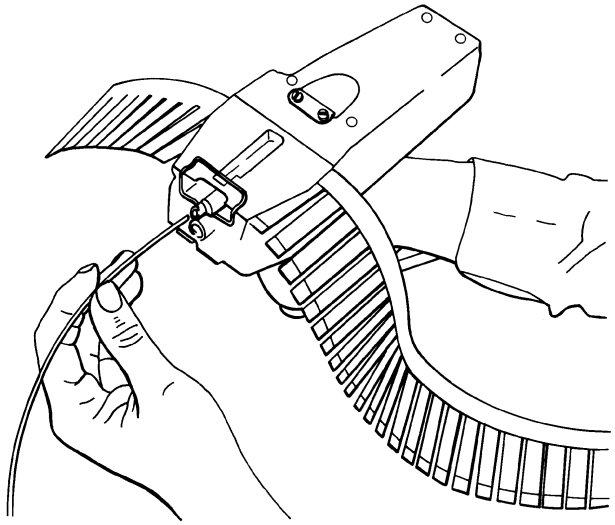
83-2855A

NOTES

b) TMS permatizer is used to photochemically lock the ink to the sleeve.

2) Installation tools

TMS-604 SLEEVE INSTALLATION TOOL

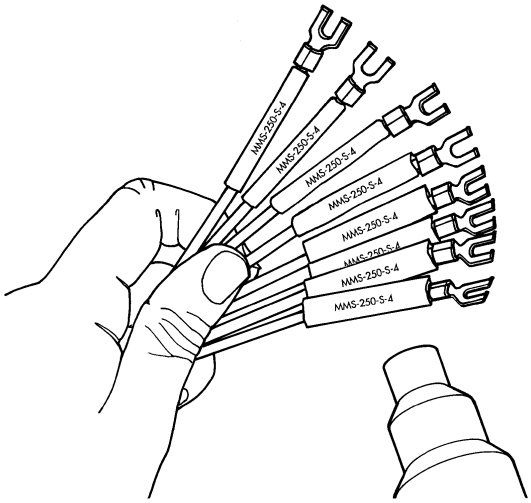


83-2856A

NOTES

3) TMS 604 sleeve installation tool mechanically removes the sleeve from the carrier and places it on the wire.

TMS SLEEVE RECOVERY

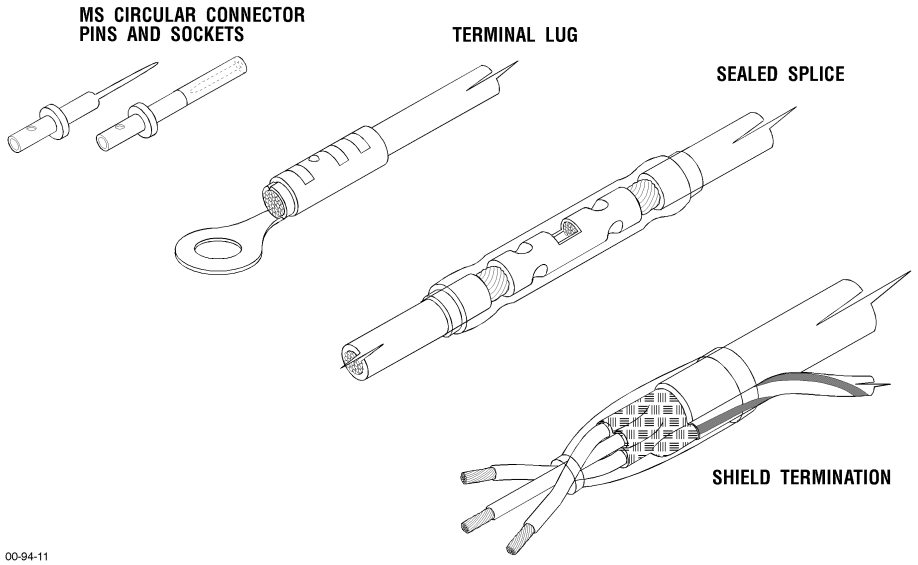


00-91-21

NOTES

4) TMS sleeve recovery is used to shrink the sleeve onto the wire thus reducing the size of the wire bundle.

WIRE TERMINATIONS



NOTES

C. Wire terminations

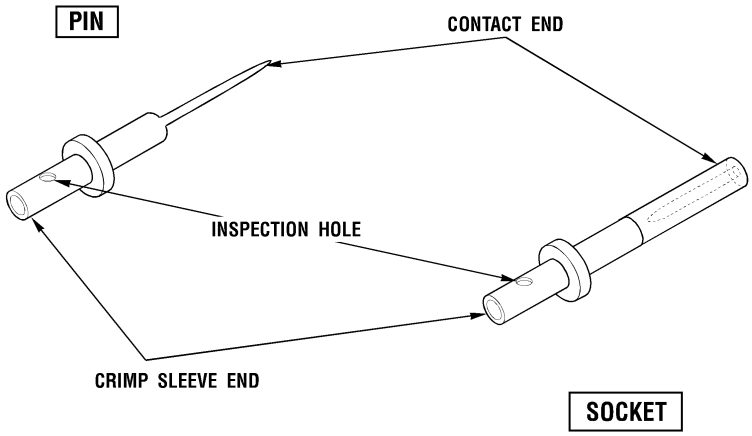
1. Wire terminations purpose and characteristics

a. Connections for electrical wiring to components in electrical and electronic systems.

b. Pins and sockets, terminal lugs, sealed splices, and shield terminations are the general types of terminations used on the AH-64A.

c. A variety of wire sizes and attaching hardware can be used.

MS CIRCULAR CONNECTOR PINS AND SOCKETS



00-94-12

NOTES

2. Pins and Sockets

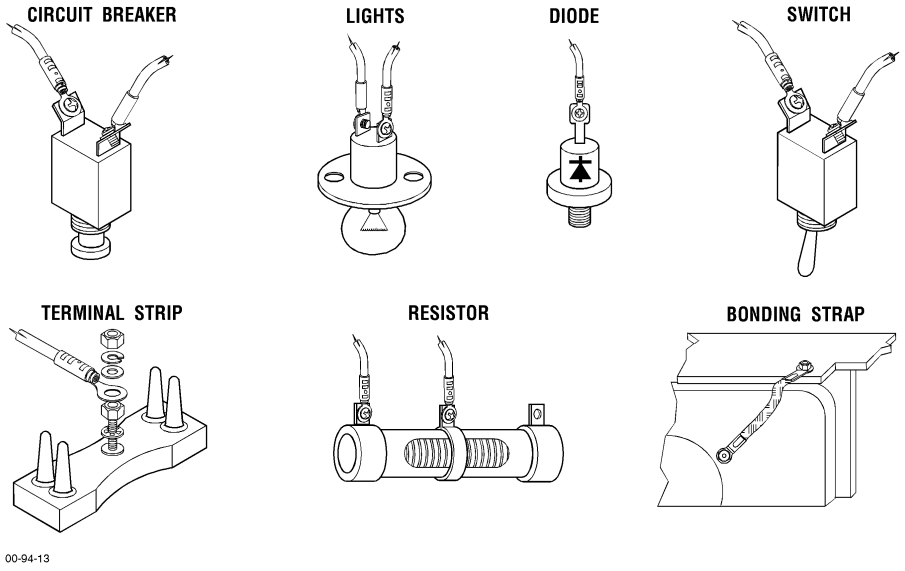
a. Pins and sockets are used to connect wiring to MS circular connectors and are used to

(1) Interconnect electrical and electronic circuits within the helicopter wiring harnesses, LRU's, and individual systems via the contact end.

(2) They can accommodate a wide range of wire and mounting hole-sizes.

(3) Wires are connected in the (sockets or pins) by crimping the sleeve end of the contact down onto the wire with the proper crimping tool.

TERMINAL LUGS



NOTES

3. Terminal lugs

a. Crimp-type terminal lugs are used to connect wiring to various components.

(1) Circuit breakers, switches, lights, and terminal posts

(2) Resistors and diodes

(3) Bonding straps, airframe grounds, and other electrical and electronic components.

(4) They can accommodate a wide range of wire and mounting hole-sizes.

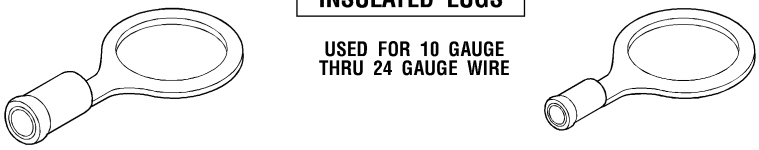
TERMINAL LUG WIRE SIZES

UNINSULATED LUGS

USED FOR 4/0 GAUGE
THRU 8 GAUGE WIRE

INSULATED LUGS

USED FOR 10 GAUGE
THRU 24 GAUGE WIRE



00-94-14

NOTES

b. Wire sizes

(1) Un-insulated lugs are used on large copper wires.

(a) Gauge 4/0 through 8

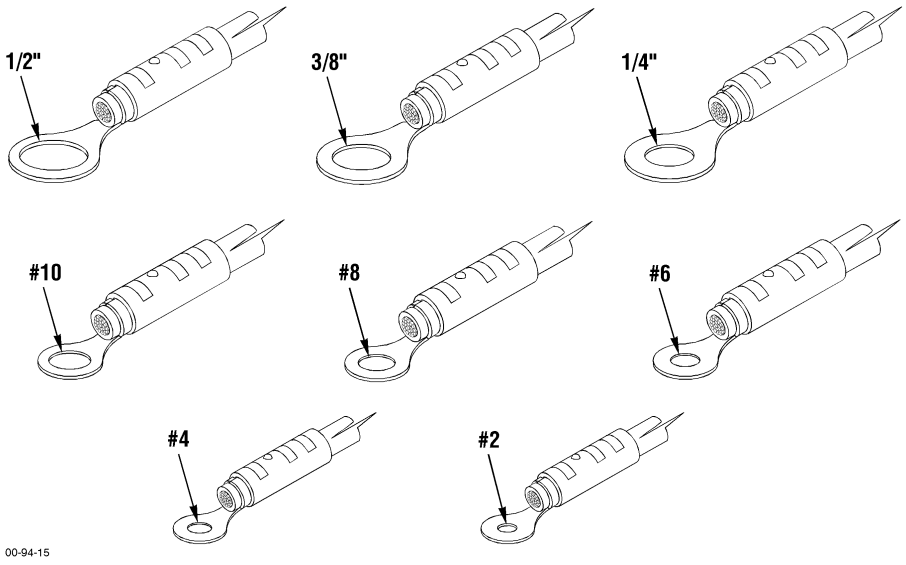
(b) Power generation and Distribution

(2) Insulated lugs are used on small copper wires.

(a) Gauge 24-10

(b) Control, switching, power to electrical and electronic systems

TERMINAL LUG MOUNTING HOLE SIZES



NOTES

c. Terminal lug mounting hole-sizes cover a wide range of standard aircraft hardware that can be used to attach a lug to a component.

(1) 1/2 inch hole diameter

(2) 3/8 inch hole diameter

(3) 1/4 inch hole diameter

(4) # 10 screw

(5) # 8 screw

(6) # 6 screw

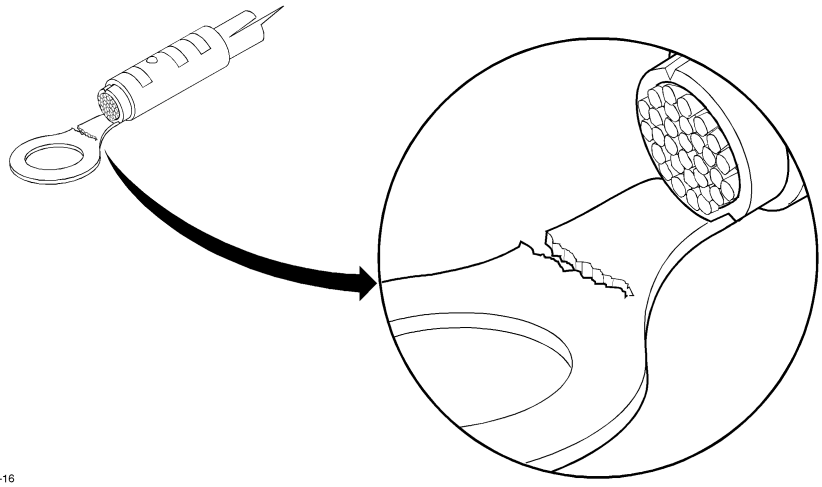
(7) # 4 screw

(8) # 2 screw

d. A wide variety of wire size and lug size combinations are available for the terminal lugs. This allows small wires to be attached to connections that use large hardware and vice-versa.

COMMON TERMINAL LUG FAILURES I

FATIGUE OR FRACTURE OF LUG ADJACENT TO MOUNTING POINT



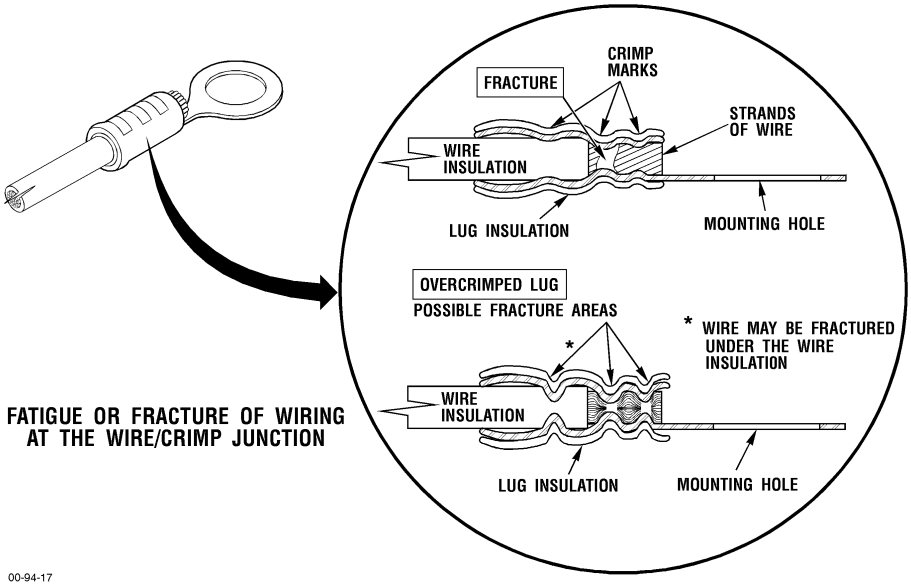
00-94-16

NOTES

e. Common terminal lug failures

(1) Fatigue or fracture of lug adjacent to mounting point. This is usually the result of bending the lug back and forth an excessive number of times.

COMMON TERMINAL LUG FAILURES II



FATIGUE OR FRACTURE OF WIRING AT THE WIRE/CRIMP JUNCTION

00-94-17

NOTES

(2) Fatigue or fracture of the wiring at the wire/lug crimp junction. This is usually the result of vibration or displacement of the wire. It may be the result of over crimping the lug to the wire.

f. Common discrepancies associated with ring-lugs

(1) Intermittent faults

(a) Ring lug loose at circuit breaker, switch or airframe ground.

(b) Wire fully or partially broken at the crimp junction.

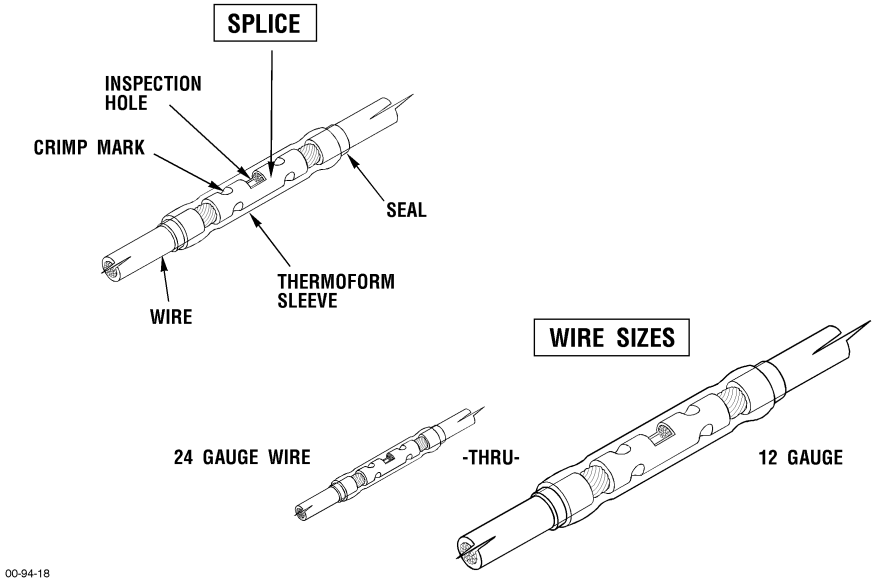
(c) Ring lug improperly crimped.

(2) Inoperative faults

(a) Ring lug fractured or hardware missing at circuit breaker, switch or airframe ground, creating an open circuit.

(b) Wire fully or partially broken at the crimp junction, creating an open circuit.

RAYCHEM® SEALED SPLICE I



NOTES

4. Raychem sealed splices

a. Raychem sealed splices are used to connect wiring to a common circuit, in a permanent manner.

(1) The splices consist of a crimp-type splice, that provides the electrical circuit, and a thremo-form sleeve.

(2) The thermo-form sleeve provides electrical insulation, protection from adverse environmental conditions (moisture, chemical, bacteria, etc) and mechanical strength for the wires and splice connections.

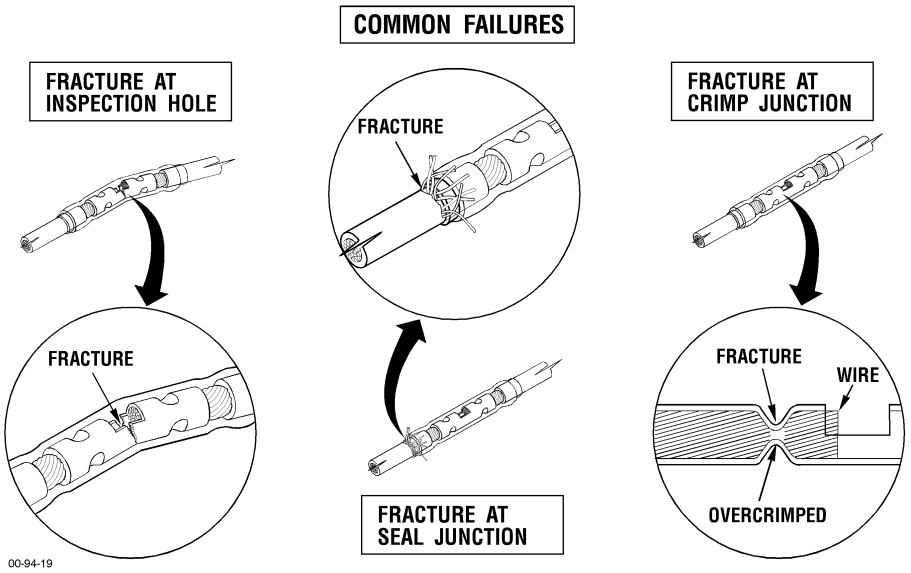
b. Wire sizes

(1) 24-12 gauge

(2) Single-wire splice

(3) Multiple-wire splice

RAYCHEM® SEALED SPLICE II



NOTES

c. Common Raychem Sealed Splice failures

(1) Fatigue and fracture of the splice adjacent to the inspection hole. This is usually the result of bending the splice.

(2) Fatigue and fracture of the wiring at the seal junction. This is usually the result of vibration or displacement of the wire. It may be the result of over crimping the lug to the wire.

(3) Fatigue and fracture of the wiring at the wire/splice crimp junction. This is usually the result of over crimping the splice to the wire.

d. Common discrepancies associated with Raychem Sealed Splices

(1) Intermittent faults

(a) Wire fully or partially broken at the crimp junction (may not be visible through the thermo-sleeve).

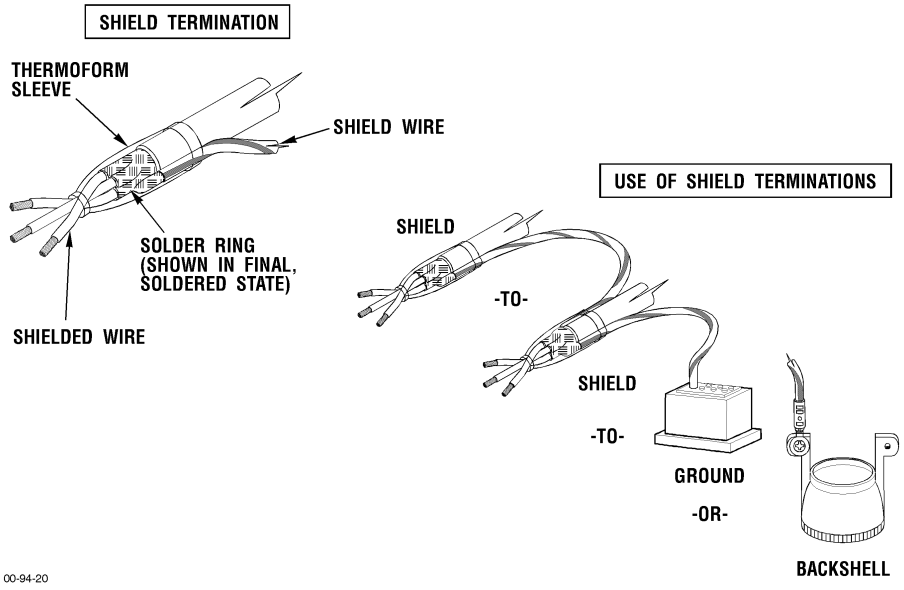
(b) Splice is improperly crimped (may not be visible through the thermo-sleeve).

(2) Inoperative faults

(a) Splice fractured, creating an open circuit. Usually the thermo-form sleeve will be broken as well.

(b) Wire fully or partially broken at the crimp junction, creating an open circuit.

SHIELD TERMINATIONS I



NOTES

5. Shield terminations

a. Shield terminations

(1) The shield terminations consist of a solder ring, a shield wire, and a thremo-form sleeve.

(2) The thermo-form sleeve provides electrical insulation, protection from adverse environmental conditions (moisture, chemical, bacteria, etc) and mechanical strength for the wires and splice connections.

(3) Are used to connect the shield of a shielded wire to complete a shield circuit to

(a) Another shield

(b) Connector backshell

(c) Ground

b. Wire sizes

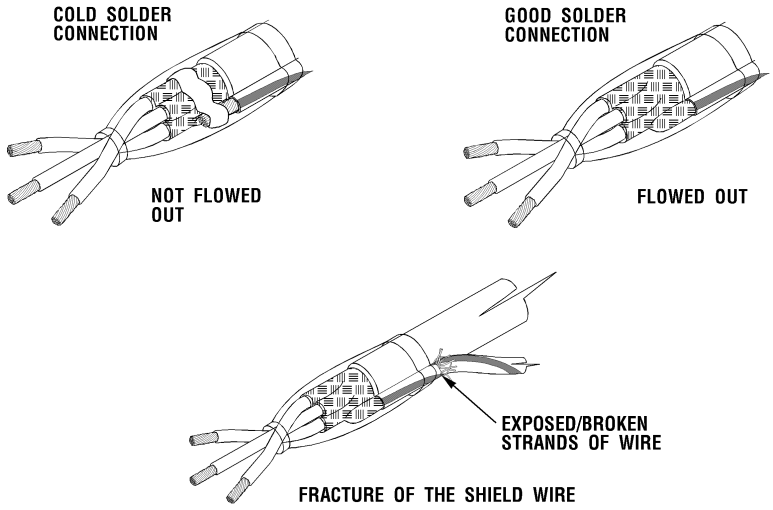
(1) 24-12 gauge

(2) Single-wire splice

(3) Multiple-wire splice

c. Integrity of shield connections is critical in some systems, particularly flight controls and communications. The shield connections must be maintained in a high state of repair to ensure proper systems operation.

SHIELD TERMINATIONS II



NOTES

d. Common Shield Termination failures

(1) A "cold solder connection" of the shield wire to the shield braid of the shielded wire or cable is one source of failure.

(a) The solder ring may still be visible in an unmelted or partially melted form.

(b) The solder will not have flowed out into the shield braid or shield wire during the assembly process.

(c) The solder may have a rough or very dull gray appearance.

(d) These are the result of improper assembly procedures (the solder ring was not heated sufficiently, to allow the solder to flow into the shield braid and the shield wire to create good electrical and mechanical connections).

(e) A high resistance current path may result, especially when vibration is present. "Noisy systems" may result from improper shield connections.

(2) The solder ring in a good connection will be flowed out evenly, present a smooth appearance, and will connect the shield braid to the shield wire with good electrical and mechanical connections.

(3) Fatigue and fracture of the wiring at the seal junction. This is usually the result of vibration or displacement of the wire.

e. Common discrepancies associated with Shield Terminations

(1) Intermittent faults

(a) Cold solder connection

(b) Wire fully or partially broken at the thermo-sleeve junction (may not be visible through the thermo-sleeve).

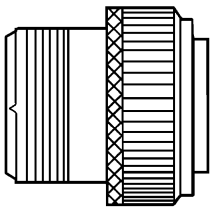
(2) Inoperative faults

(a) Wire fully or partially broken at the thermo-sleeve junction, creating an open circuit.

(b) Use of excessive heat during the assembly process has melted the insulation on the circuit wires in the shielded cable and has caused a short circuit to ground, between the operating circuits wires and the shield.

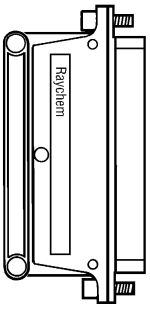
CONNECTOR IDENTIFICATION

CIRCULAR



"MS 345 " SERIES

RECTANGULAR



"HS 4894 " SERIES

83-1169A

NOTES

D. Electrical connectors utilized on the AH-64A are circular and rectangular types.

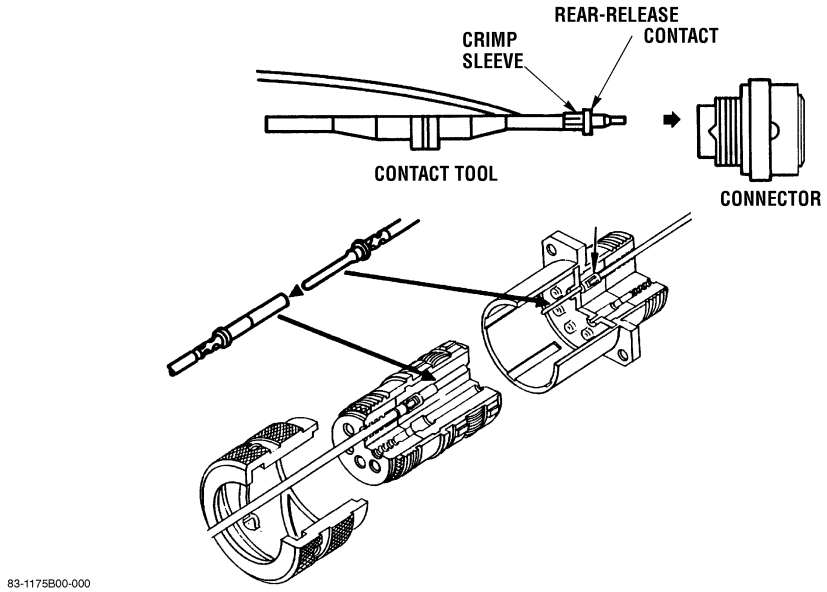
1. Connectors are used to provide common connection points for the helicopter wiring harnesses and the individual systems.

a. The connectors simplify the removal and replacement of line replaceable units during maintenance actions.

b. They are identified by "MS" (Military Specification) numbers or a Hughes (HS) part numbers, respectively.

NOTES

REAR RELEASE CONTACTS



2. MS circular connectors

a. MS circular connector components

(1) Receptacle body with tine locks

(2) Plug body with tine locks

(3) Coupling ring

(4) Contact types

(a) Pins

(b) Sockets

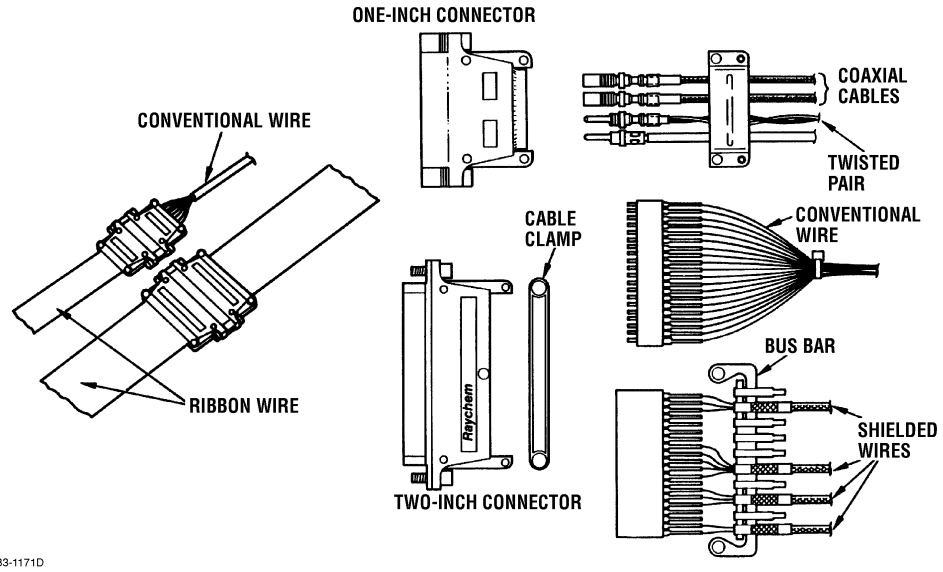
b. Wires are mounted in the contacts (sockets or pins) by crimping the crimp sleeve end of the contact down onto the wire with the proper crimping tool.

(1) The contacts are inserted into, or removed from the rear of the connector body, by utilizing the common contact tool.

(a) During insertion, the contact is gently pushed into place with the common contact tool, until the tine lock snaps down to secure the contact.

(b) During removal, the common contact tool is gently pushed into place, around the wire and contact, until the tine lock is released. The wire and common contact tool are firmly held together and gently removed together.

RECTANGULAR CONNECTORS



NOTES

3. Multiple Termination Connectors

a. Multiple Termination Connectors (MTC) are rectangular, flat and high density connectors.

(1) Used in making environmentally protected electrical connections between wire harnesses and LRU's.

(2) MTC connectors come in one inch and two-inch widths. The two-inch connector has 40 contacts; the one inch has 20.

(3) A variety of wire types and sizes can be used.

(a) Ribbon wire

(b) Conventional wire

(c) Coaxial cables

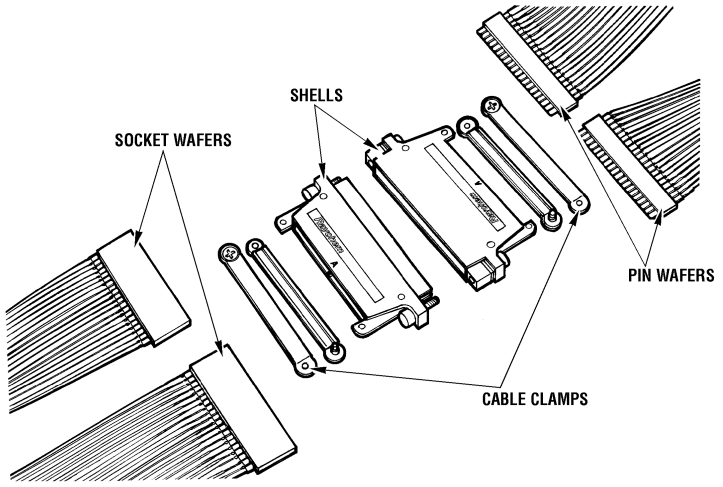
(d) Twisted pair cables

(e) Shielded wires

b. The shield circuits for shielded wiring are carried through the connecter by utilizing a bus bar.

c. Cable clamps are used to hold the wires and to prevent stress on the terminal connections.

RECTANGULAR CONNECTOR COMPONENTS



00-91-04

NOTES

d. The multiple termination connector components

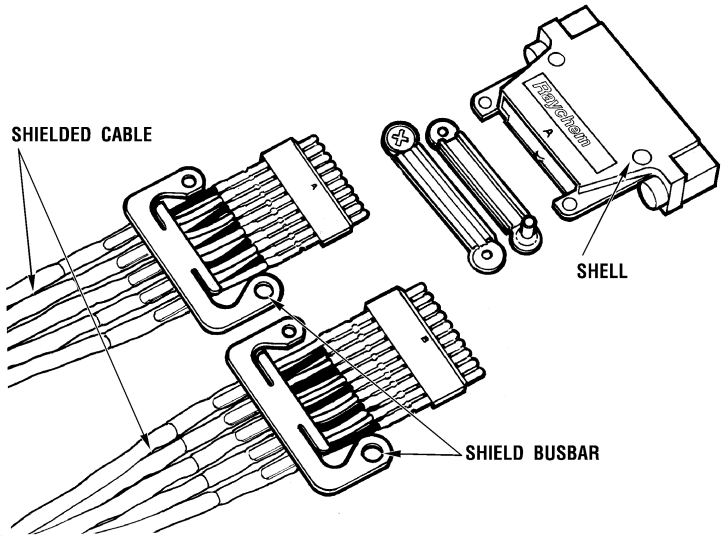
(1) Shells

(2) Cable clamps

(3) Pin wafers

(4) Socket wafers

SHIELDED CABLE CONNECTORS



NOTES

e. Shielded cable connectors

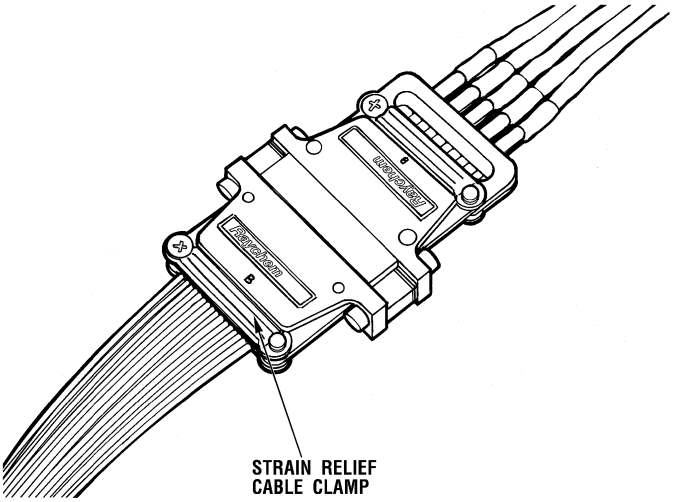
(1) The shield circuits for shielded wiring are carried through the connector shell by using a multi-fingered bus-bar and individual solder sleeves.

(2) Shielded cable is handled and terminated in a manner similar to primary wire.

(3) Each two-inch wafer can accommodate up to 10 twisted shielded pairs.

(4) One-inch wafers can accommodate up to five shielded pairs.

BUSBAR CONNECTION

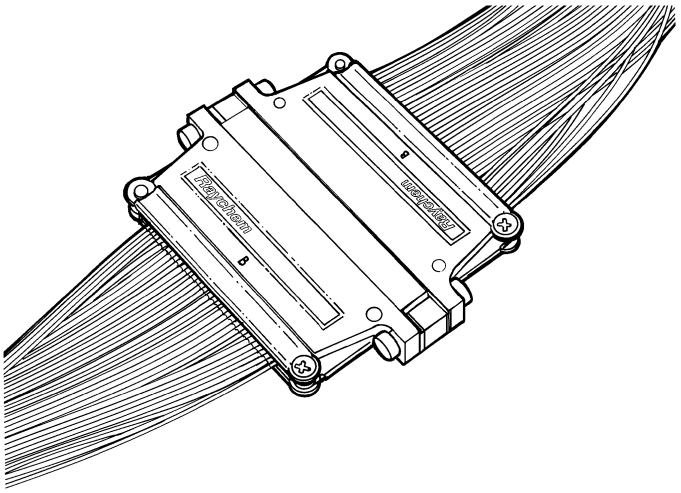


00-91-17

NOTES

(5) The busbar is connected to the strain relief cable clamp at the rear of the connector shell.

RECTANGULAR CONNECTOR ASSEMBLED

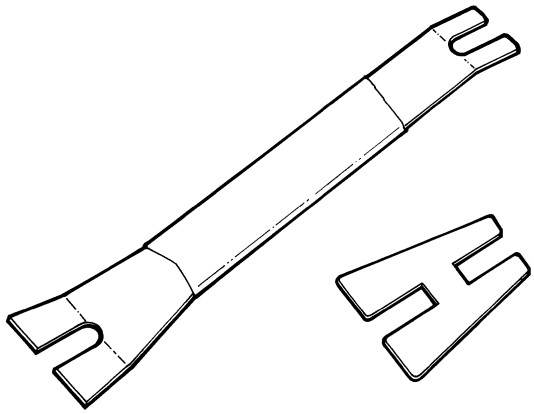


00-91-05

NOTES

f. An assembled connector is held together by jack screws, one on each side of the shell.

WAFER EXTRACTION TOOLS



00-91-11

NOTES

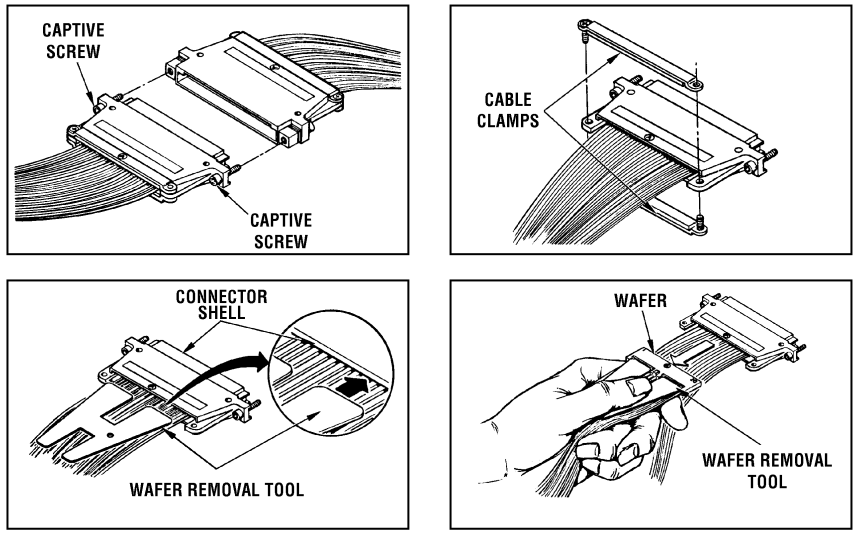
g. A wafer extraction tool is used to remove wafers from the shells.

(1) The tool comes in two sizes.

(a) The smaller size is made of plastic.

(b) The larger is made of metal (care must be used to prevent damaging the wire insulation).

WAFER REMOVAL



83-3198

NOTES

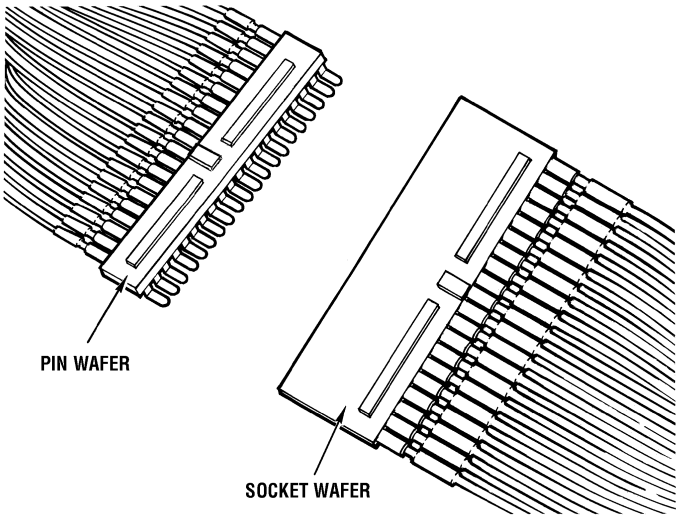
h. Wafer removal

(1) Disassemble the connector by loosening the captive screws.

(2) Remove cable clamps and insert wafer removal tool between wafer and connector shell until tool locks into place.

(3) Pull on the tool and wires connected to wafer until the wafer is free of the lock. Pull the wafer the rest of the way out of the connector. Once the first wafer is free the second wafer will slide out very easily. The removal tool may not be required to remove the second wafer.

CONTACT CONFIGURATION



00-91-07

NOTES

i. There are two wafer contact configurations.

(1) Pin wafer, used with receptacle type shell

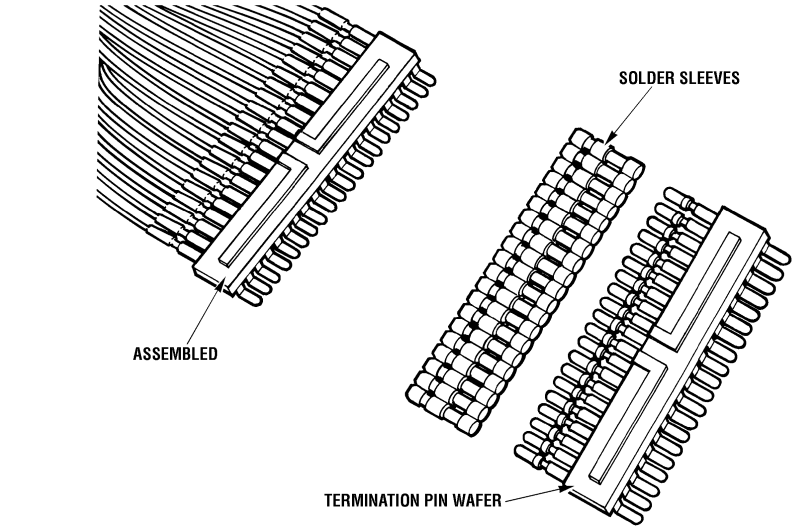
(2) Socket wafer, used with plug-type shell

(3) Each pin and socket wafer

(a) Comes in an "A" designated wafer and a "B" designated wafer.

(b) The designations are used to align the wafers to the A and B sides of the shell housing when they are inserted.

RECTANGULAR CONNECTOR TERMINATIONS



NOTES

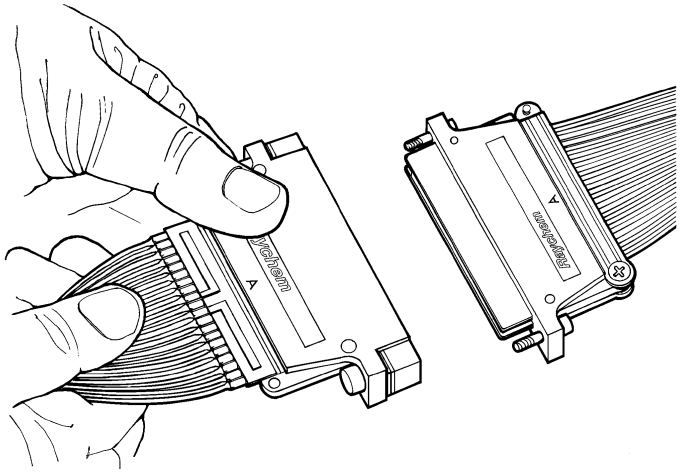
(4) Wire is terminated to the wafers by means of solder sleeves.

(a) Strips of 10 and 20 solder sleeves are used when mass terminating one inch and two inch cable connectors.

(b) The yellow-colored insert-end of the sleeve should always be installed on the wafer side of the terminal.

(c) The yellow and pink materials are meltable sealant inserts.

WAFER INSERTION



00-91-08

NOTES

WARNING

ELECTRICAL POWER

Electrical power operating or maintenance procedures, practices or conditions, which, if not strictly observed, could result in injury or death to personnel. These WARNINGS must be strictly obeyed by all personnel.

j. Wafer insertion

(1) The insertion of the wafers requires stacking the A and B wafers together and aligning them properly to the A and B sides of the shell.

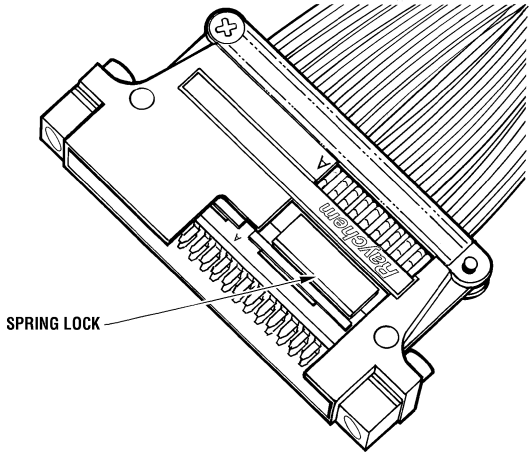
(a) Incorrect alignment will cause the circuits connected by the pin and socket wafers to be incorrect when the plug and receptacle are assembled.

(b) This could result in death or injury to crewmembers and/or maintenance personnel, or cause equipment damage.

(2) Once proper alignment is verified, the wafers are gently pushed into the shell until they lock into place.

(3) The same technique is used, whether inserting the pin wafers into receptacle-type shells, or inserting socket wafers into plug-type shells.

WAFER RETENTION

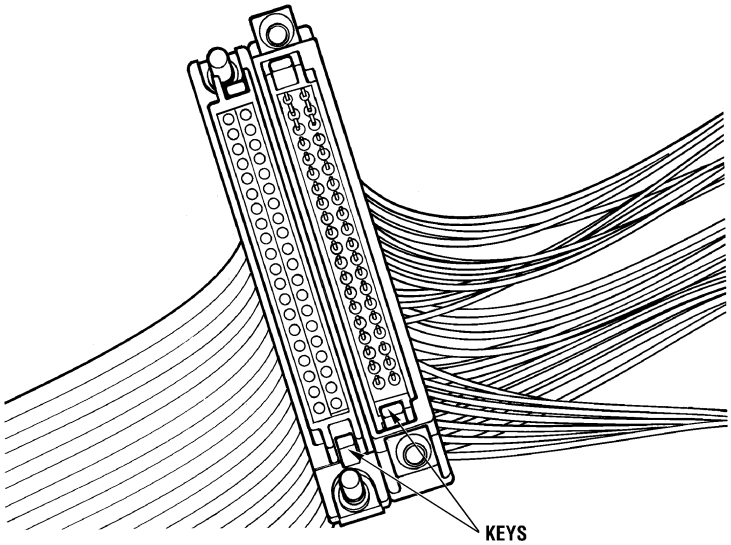


00-91-09

NOTES

(4) When the wafers are inserted into the shell they are held in position by a metal spring member that locks behind a molded retention rib on each wafer.

OFFSET MATING



00-91-10

NOTES

WARNING

ELECTRICAL POWER

Electrical power operating or maintenance procedures, practices or conditions, which, if not strictly observed, could result in injury or death to personnel. These WARNINGS must be strictly obeyed by all personnel.

k. Offset Mating

(1) Each connector housing is polarized and has 16 keying combinations.

(a) The two (2) ends of the connector have provision for keying inserts to establish the mating polarity for the connector.

1) Each end has four (4) possible key positions.

2) The total number of combinations for any rectangular connector is sixteen.

$$(4)^2 = 16$$

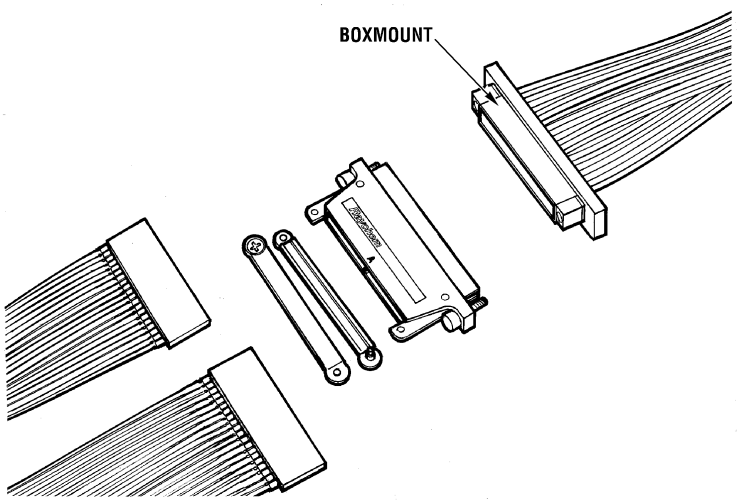
(b) This quantity is sufficient to provide an adequate number of combinations so that no two connectors in close proximately will have the same keying combination.

1) This will minimize the possibility of connectors being mis-mated.

2) The connectors can be mis-mated, however; if excessive force is applied to the connectors during connection.

(2) If a connector is replaced for any reason, the proper key polarization must be installed in the new connector. This minimizes the possibility of connecting it to the wrong connector.

BOXMOUNT CONNECTOR



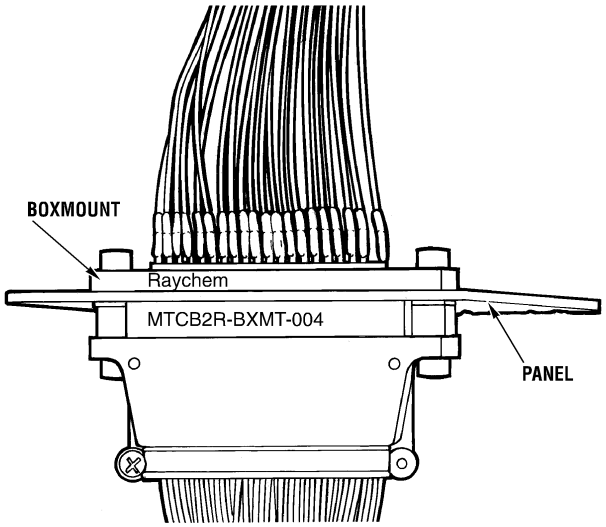
00-91-12

NOTES

4. Boxmount connectors

   a. The boxmount connector is a single-piece fixed connector available in two inch size only.

BOXMOUNT-PANEL MOUNTED

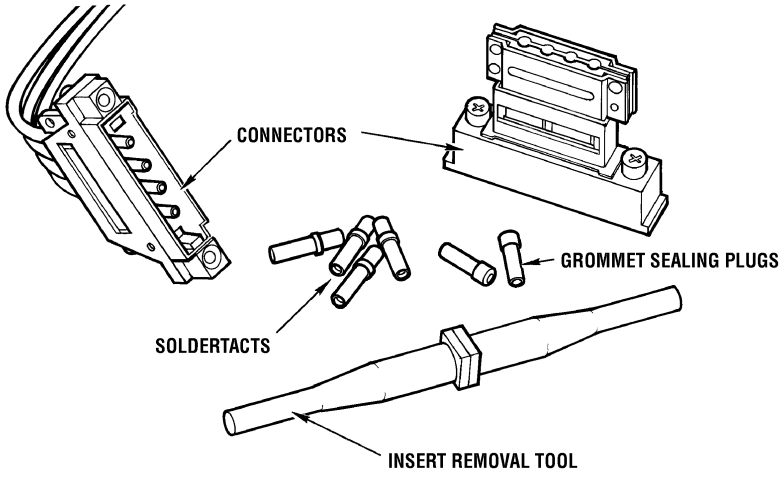


00-91-13

NOTES

b. The boxmount connector has 40 pin contacts on its mating end. It mates with two inch plug connectors with socket wafers.

MTX COAX CONNECTORS



00-91-20

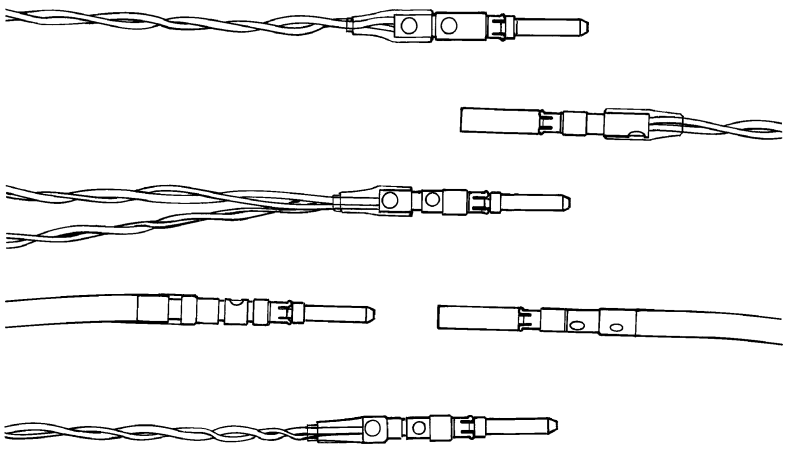
NOTES

5. MTX coax connectors are specially designed rectangular housings.

   a. The MTX coax connectors are similar in appearance to other rectangular connectors, but the inserts are not removable wafers. The insert can hold four soldertact coaxial-type contacts.

   b. The contact retention system used in the MTX coax connector is a rear-release system, similar to the type utilized in MS circular connectors. The insert removal tool is used to remove and insert soldertact contacts.

SOLDERTACT CONTACTS

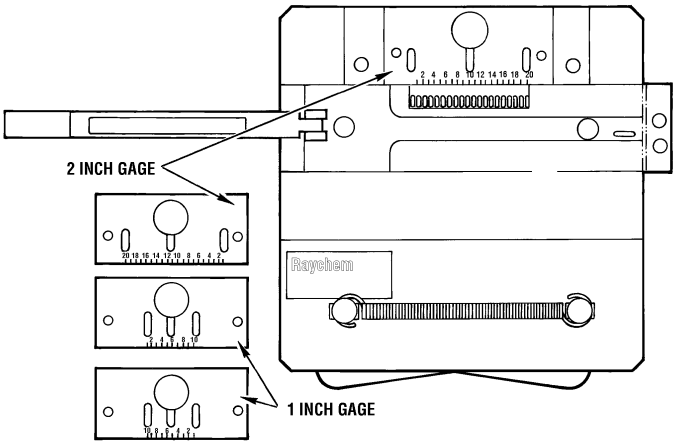


00-91-19

NOTES

c. Soldertact contacts are one piece, shielded contacts used to terminate coaxial cables, shielded wires, or twisted pairs to a one piece contact. They are used with MTX coax connectors.

BENCH TERMINATION FIXTURE



00-91-14

NOTES

E. MTC termination fixtures are used to hold MTC wafers, while wires are being connected to the wafer terminals during manufacture or repair.

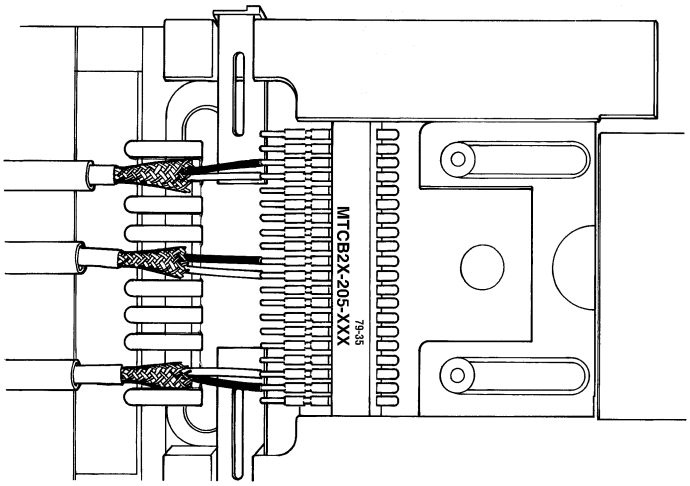
1. Bench termination fixture

a. Bench termination fixtures are used to repair rectangular connectors in the shop.

b. The fixture allows individual, or multiple termination of wires. It will accommodate different wire gauge sizes on the same one inch or two inch wafer.

.

SHIELD TERMINATION FIXTURE

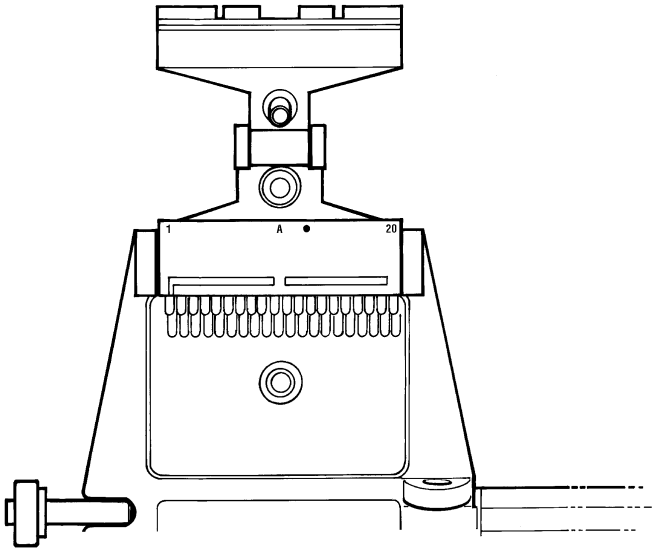


00-91-18

NOTES

2. The shield termination fixture is used to solder cable shields to shield bus-bars.

MAINTENANCE REPAIR FIXTURE



00-91-15

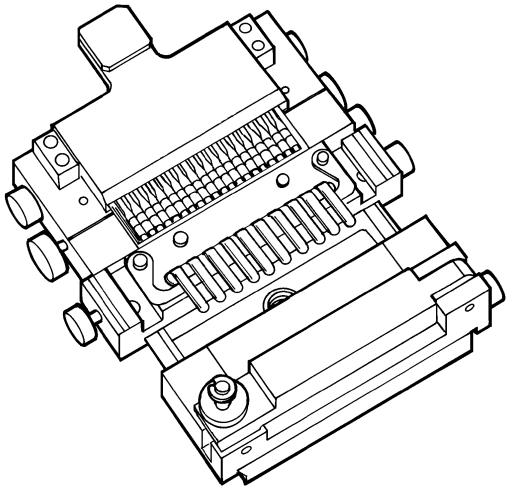
NOTES

3. Maintenance repair fixture

   a. The maintenance repair fixture is used when a connector cannot be removed from the aircraft for repair.

   b. The maintenance repair fixture is similar in operation to the bench termination fixture.

UNIVERSAL TERMINATION FIXTURE (1)

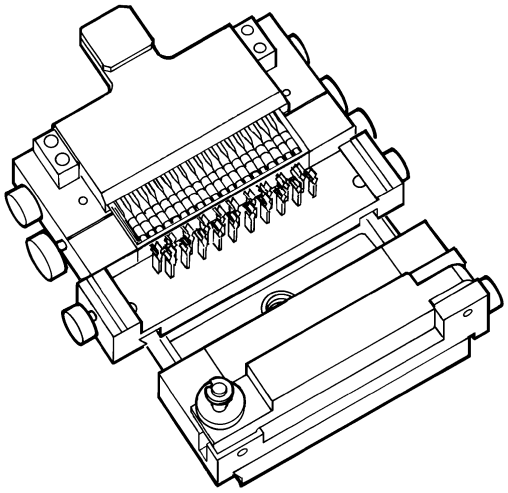


00-91-01

NOTES

4. Universal termination fixture is used in place of the bench termination and shield termination fixtures. A wafer and shield bus bar are shown installed in the fixture.

UNIVERSAL TERMINATION FIXTURE (2)

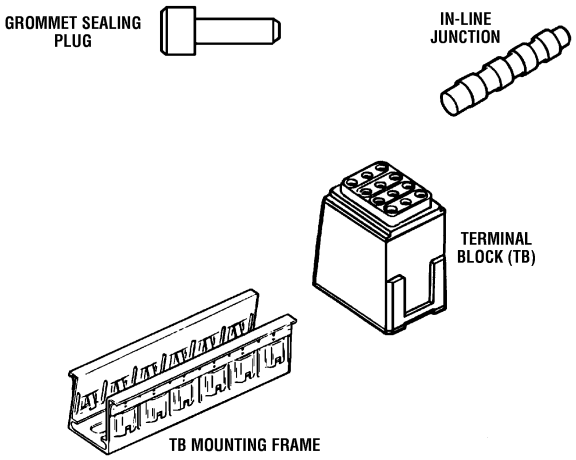


00-91-02

NOTES

5. Universal termination fixture is shown with a wafer installed.

COMMON TERMINATION SYSTEM (CTS)



NOTE: ELECTRONIC TB, FEEDTHROUGH TB AND GROUND STUD TB ARE OF THE SAME SIZE AS THE TERMINAL BLOCK SHOWN ABOVE. RELAY MODULES ARE SAME SIZE ONLY HAVE PINS.

83-1176A

NOTES

F. The Common Termination System provides a simple way to install terminal buses, relays, splices, and ground studs.

1. CTS components

a. Terminal block (TB) mounting frame

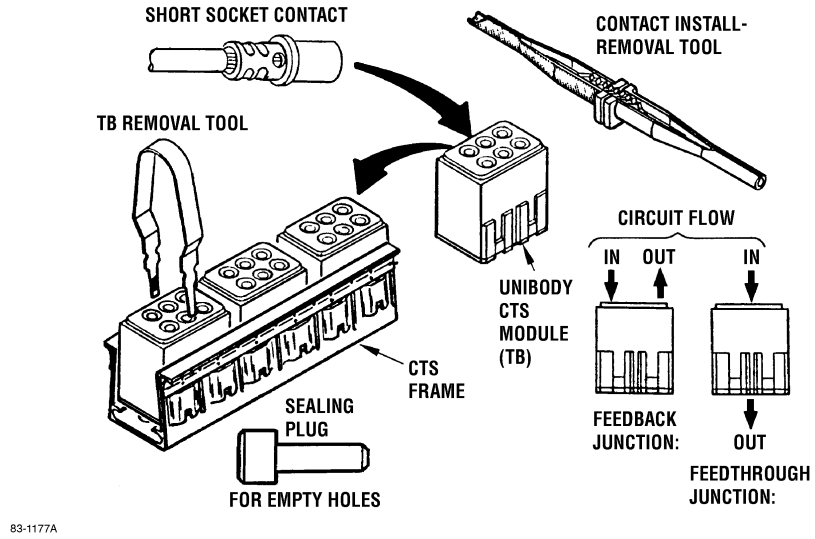
b. Terminal block

c. Grommet sealing plug

d. In-line junctions

e. Splice

CTS TERMINAL BLOCK COMPONENTS



NOTES

2. Terminal blocks

   a. All TB's on the AH-64A utilize short socket contacts and require a common contact install-removal tool for installation or removal.

   b. A terminal board removal tool is used to remove TB's from the frames.

   c. The sealing plug is used to plug empty sockets (holes).

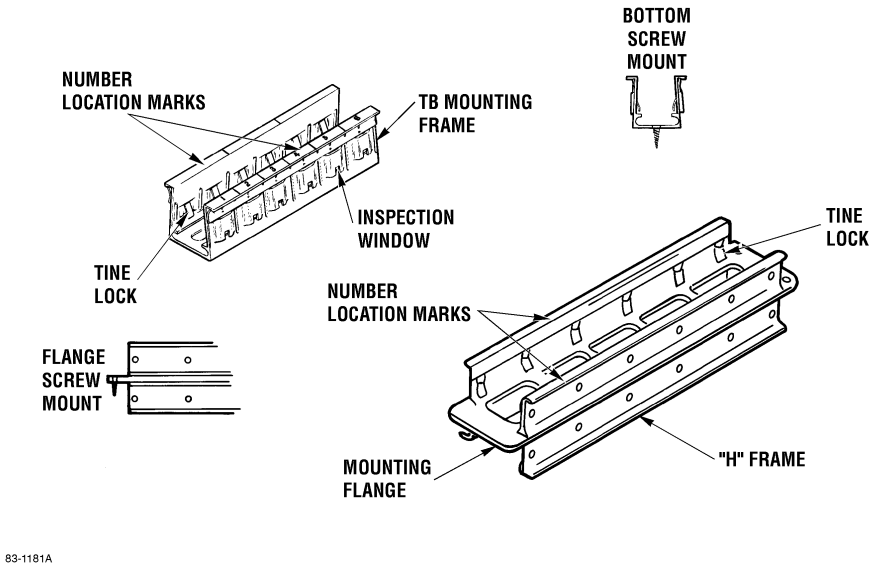
   d. There are two types of TB's.

      (1) Feedback junctions

      (2) Feed through junctions

   e. When installing TB's or relay modules, a loud click will be heard when the locking tines engage the TB modules. The TB mounting frame also incorporates an inspection window to check installation.

CTS MOUNTING FRAMES



NOTES

3. CTS mounting frame description

a. "H" frame

(1) Used to mount feed-through terminal blocks and relay modules.

(2) Mounted on equipment by flange screw mount.

(3) Number location marks identify the TB's and relay modules.

(4) Comes in lengths of 2 to 7 inches.

b. TB mounting frame

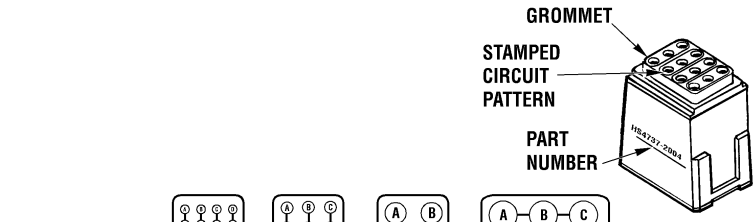
(1) Used to mount feed-back terminal blocks.

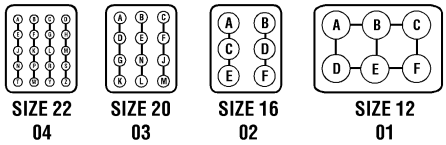
(2) Bottom screw mounted.

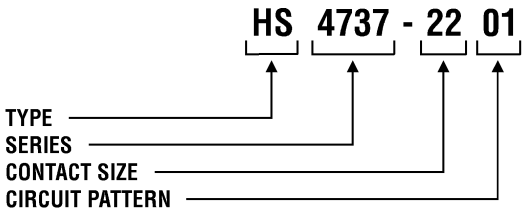
(3) Number location marks identify the TB's.

(4) Comes in lengths of 2 to 12 inches.

ELECTRICAL TB IDENTIFICATION







83-1178

NOTES

c. The circuit pattern is stamped on the grommet and is also identified by the part number.

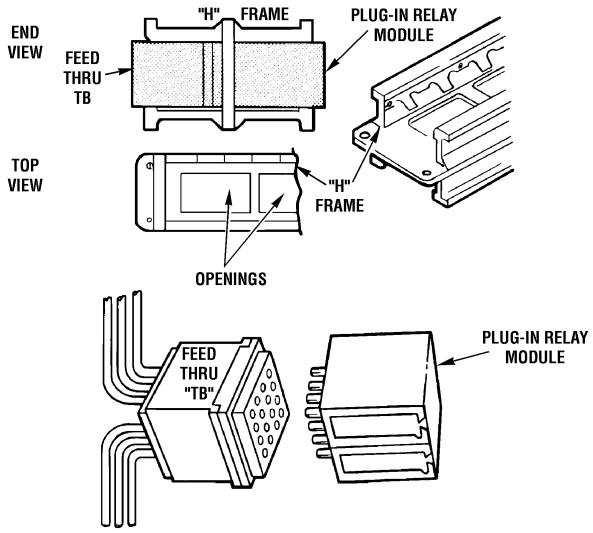
d. Feedback junctions provide an easy method to connect several wires to a common circuit.

(1) A variety of wire sizes can be utilized

(2) Feedback junctions come in four circuit patterns.

(3) Feedback junctions plug into the "H" frames and are held in place by the tine locks.

FEEDTHROUGH TBs AND ELECTRONIC MODULES



83-1064-2B

NOTES

e. Feedthrough TB's provide an easy method for relay modules to be incorporated into the aircraft circuitry.

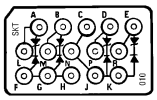
(1) Six different relay contact configurations are available for the CTS system.

(a) Feedthrough TB's come in six different circuit patterns to accommodate the different CTS relay types.

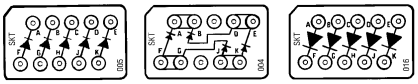
(b) Relay modules plug into feedthrough TB's and are held in place by the tine locks in the "H" frames.

ELECTRONIC TBs

HS4780-01

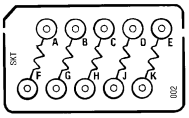


HS 4790-01, 02 OR 03



-01 -02 -03

HS 5066-01



83-1179

NOTES

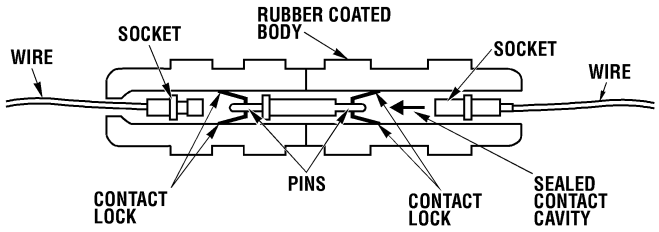
f. Electronic terminal blocks are for special applications that require diodes, zener diodes, and/or resistors built into the circuit. They come in three different types.

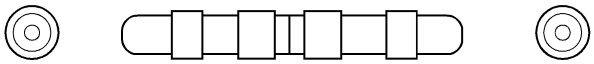
(1) HS-4780-01 is an arc suppressor TB using diodes and zener diodes; used to bleed the magnetic field of relays.

(2) HS-4790-01, 02, or 03 are diode TB's; the dash number indicates circuit pattern.

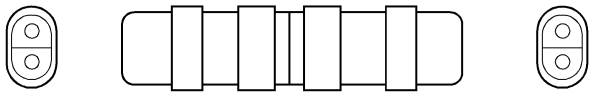
(3) HS-5066-01 is a resistor TB.

CTS IN-LINE JUNCTION





SINGLE SPLICE



DOUBLE SPLICE

83-1182

NOTES

4. CTS In-line junctions (splices) connect wiring to a common circuit.

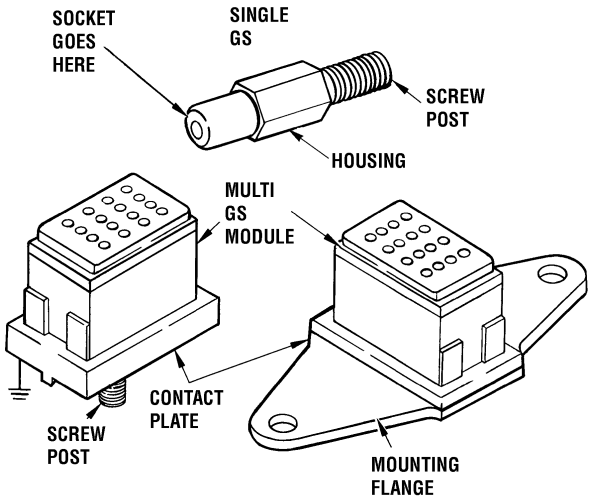
   a. The CTS in-line junctions differ from other pre-insulated and un-insulated splices, in that the CTS contacts can be removed and installed without damaging the splice.

      (1) CTS splices come in single or double-wire splices.

      (2) CTS splices are insulated by a silicone rubber on the outside.

      (3) The contacts are removed and installed using the contact install-removal tools.

CTS GROUND STUDS



NOTES

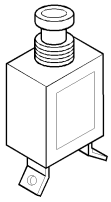
5. CTS ground studs are used for single and multiple ground connection.

   a. Each input is connected to a bottom contact plate which is screw or flange mounted to airframe ground.

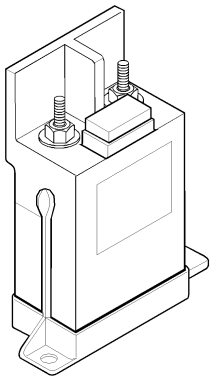
   b. The contacts can be removed and installed without disturbing the ground stud or other contacts.

CIRCUIT PROTECTION COMPONENT TYPES

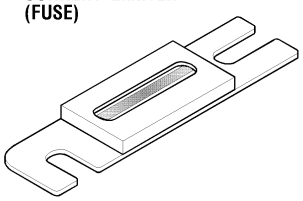
MANUALLY RESETTABLE CIRCUIT BREAKER



REMOTE CONTROLLED CIRCUT BREAKER (ELECTRICALLY RESETTABLE)



REPLACEABLE CURRENT LIMITER (FUSE)



00-94-22

NOTES

A. Circuit protection

1. Circuit protection provides current overload protection for AH-64A electrical and electronic systems in case of equipment failure or battle damage. The protection includes the AC and DC electrical power sources, wiring, and the associated equipment receiving electrical power.

2. The circuit protection system components

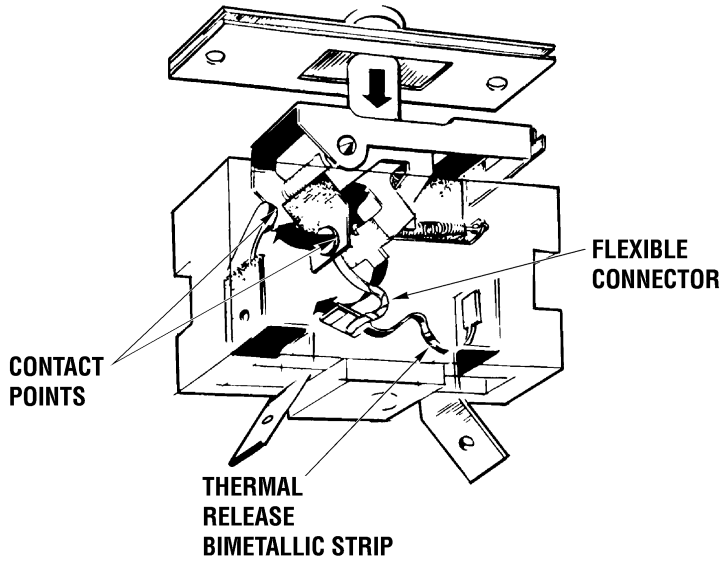
a. Thermally operated, manually resetable circuit breakers.

b. Thermally operated, electrically resettable circuit breakers.

c. Replaceable current limiters (fuses).

d. The type of circuit protection device varies according to application. They are mounted on circuit breaker panels in the pilot crewstation, CPG crewstation, electrical power center, left and right wings, aft equipment bay, and the aft avionics bay.

THERMAL CIRCUIT BREAKER



83-1050A

NOTES

3. Description

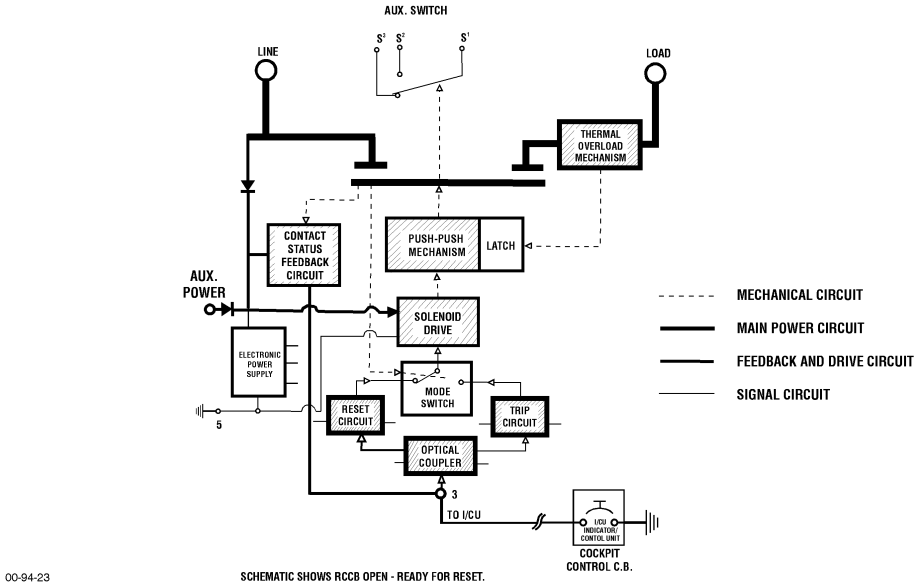
a. Manually resettable, thermal circuit breaker components

(1) Thermal release bi-metallic strip

(2) Flexible connector

(3) Contact points

REMOTE CONTROLLED CIRCUIT BREAKER (RCCB)



00-94-23

SCHEMATIC SHOWS RCCB OPEN - READY FOR RESET.

NOTES

b. Thermally operated, electrically resetable Remote Control Circuit Breakers (RCCB's)

(1) Are used to place the circuit protection close to the device that is being protected. This ensures that the maximum operating current and voltage are available to the device being protected, that the protection response time is improved, and that the remote circuit breaker can be reset from a convenient location.

(2) Heat generated by excessive current causes an uneven expansion of the bimetallic strip and activates the thermal overload mechanism.

(3) This causes the contactor portion of the RCCB to open and activates the feedback circuit to the Indicator/Control Unit (I/CU), opening the circuit breaker.

(4) Conditions for the RCCB ready-for-reset state

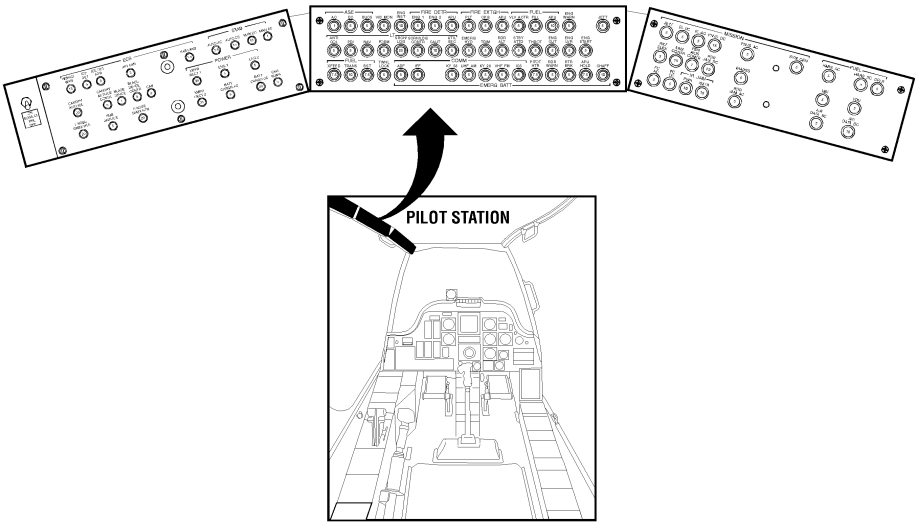
(a) The RCCB cannot be reset until the fault condition is cleared.

(b) The thermal overload mechanisim bimetallic strip must cool.

(5) The controllable contactor is resettable through the manual I/CU circuit breaker in the cockpit. The I/CU controls the optical/reset circuit and closes the contactor portion of the RCCB through the solenoid drive and push-pull mechanism.

(6) Load and control connections are made at the desired location, providing maximum protection and controllability.

PILOT CIRCUIT BREAKER PANELS



09-94-05
83-1164

NOTES

4. Location

a. The pilot crewstation circuit breaker panel is located overhead, attached to the left over-head canopy bow. It is made up of three circuit breaker sub-panels that contain manually resettable circuit breakers.

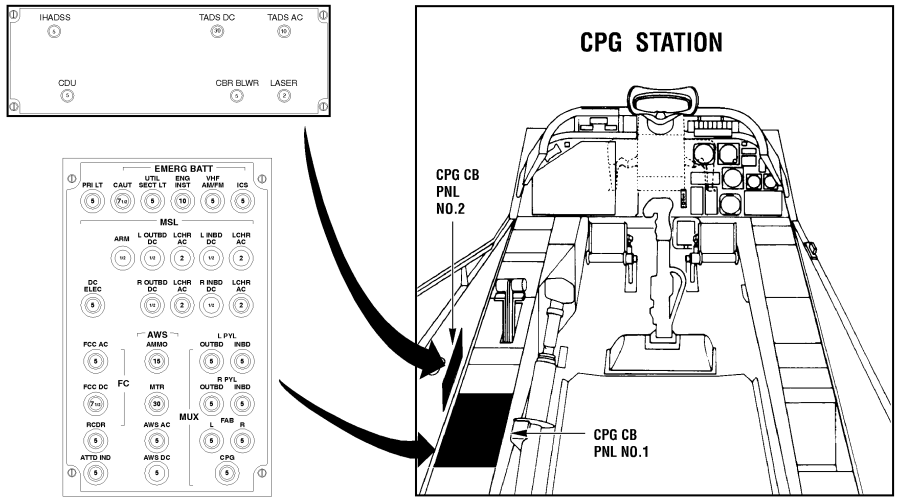
(1) Forward circuit breaker panel.

(2) Center circuit breaker panel.

(3) Aft circuit breaker panel.

(4) The individual circuit breakers are labeled as to the system they protect and the maximum current value which they will maintain under standard conditions.

CPG CIRCUIT BREAKER PANELS



09-94-02
83-1165

NOTES

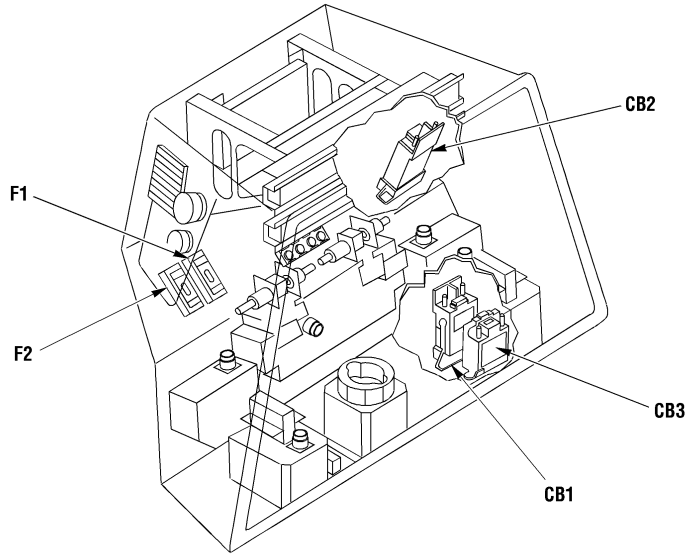
b. The CPG circuit breaker panels contain manually resettable circuit breakers. They are located on the left side of the CPG station.

(1) No. 1 panel is located in the left console.

(2) No. 2 panel is located in the crewstation left side panel.

(3) The individual circuit breakers are labeled as to the system they protect and the maximum current value which they will maintain under standard conditions.

CIRCUIT PROTECTION COMPONENTS
ELECTRICAL POWER CENTER



00-94-24

NOTES

c. Thermally fused, replaceable current limiters are mounted in the electrical power center. They provide protection for portions of the fire control and mission equipment systems.

(1) F1 provides protection for the left wing Hellfire RCCB's

(a) RCCB SEEKER 1 (CB201)

(b) RCCB SEEKER 2 (CB202)

(2) F2 provides protection for the right wing Hellfire RCCB's

(a) RCCB SEEKER 2 (CB203)

(b) RCCB SEEKER 3 (CB204)

d. Thermally operated, electrically resettable Remote Control Circuit Breakers (RCCB's) are mounted in the electrical power center and the left and right wings. They provide protection for portions of the fire control and mission equipment systems.

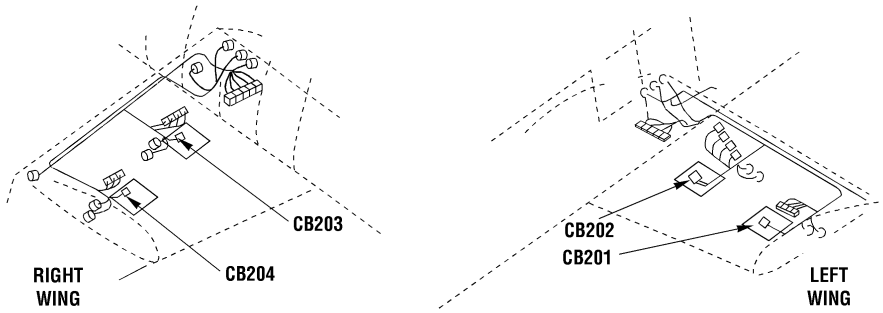
(1) Electrical power center (A402) RCCB's

(a) Radar jammer power RCCB (CB1)

(b) IR jammer power RCCB (CB2)

(c) ARM RCCB, fire control power is the arm power for pylon launchers (CB3).

CIRCUIT PROTECTION COMPONENTS – LEFT AND RIGHT WING RCCB'S –



00-94-25

NOTES

(2) Left wing Hellfire RCCB's provide protection for stations 1 and 2 Hellfire missile seekers.

(a) RCCB SEEKER 1 (CB201) for wing station number one.

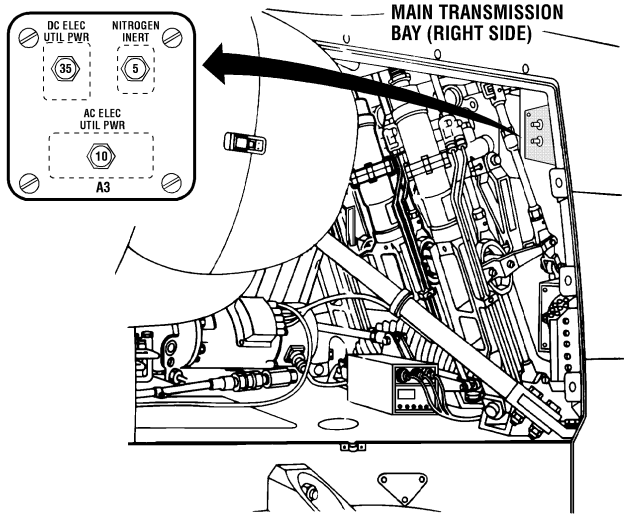
(b) RCCB SEEKER 2 (CB202) for wing station number two.

(3) Right wing Hellfire RCCB's provide protection for stations 3 and 4 Hellfire missile seekers.

(a) RCCB SEEKER 3 (CB203) for wing station number three.

(b) RCCB SEEKER 4 (CB204) for wing station number four.

MAIN TRANSMISSION BAY CIRCUIT BREAKERS



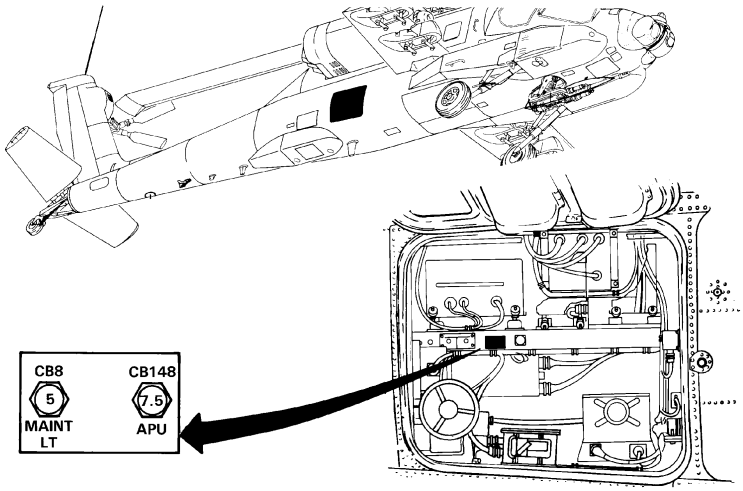
83-1166

NOTES

e. The main transmission bay circuit breakers are located on a panel on the right side of the bay.

(1) The individual circuit breakers are labeled as to the system they protect and the maximum current value which they will maintain under standard conditions.

AFT AVIONICS BAY CIRCUIT BREAKERS



09-92-02

NOTES

f. The aft avionics bay circuit breakers are mounted on the center shelf, outboard, longitudinal support rail.

(1) The individual circuit breakers are labeled as to the system they protect and the maximum current value which they will maintain under standard conditions.

BASIC ELECTRICAL THEORY

- CURRENT AND VOLTAGE GENERATION
- AC GENERATORS - ROTATING COIL
- AC GENERATORS - ROTATING MAGNET
- GENERATOR LIMITING FACTORS
- FREQUENCY DETERMINATION
- PHASE DETERMINATION
- AH-64 GENERATOR OUTPUT SPECIFICATIONS

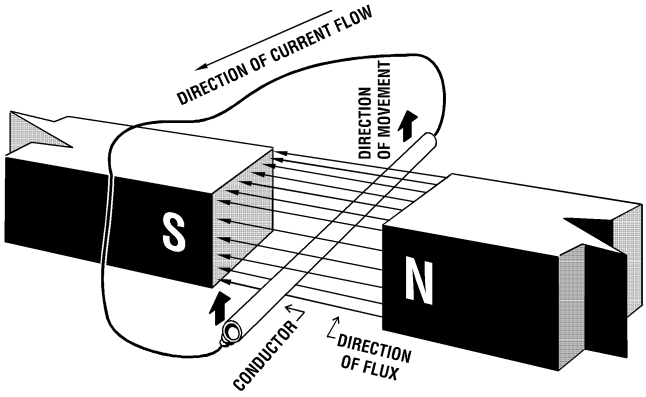
09-94-07

NOTES

A. A knowledge of basic electrical theory is essential to understanding the operation of the AH-64 AC and DC power generation systems. Current Generation Theory, AC Generator Theory, Generator limiting factors, Frequency Determination of an AC Generator, Phase Determination of an AC Generator, and AH-64A generator output specifications will be discussed.

CURRENT AND VOLTAGE GENERATION THEORY I

ELECTROMAGNETIC INDUCTION



09-94-08

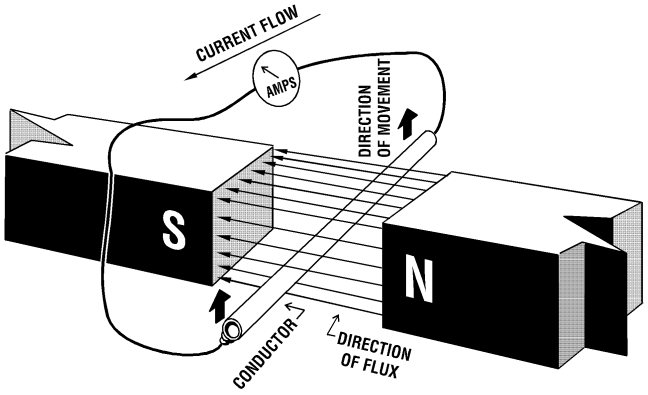
NOTES

1. Current and Voltage Generation Theory

   a. When an electrical conductor (wire) moves at right angles to a magnetic field, electrons are caused to flow in that wire. The generation of electron flow by moving the wire in the presence of a magnetic field is called electromagnetic induction.

CURRENT AND VOLTAGE GENERATION THEORY II

CURRENT MEASUREMENT



09-94-09

NOTES

b. The current can be measured by placing an current meter (known as an ammeter) in series with the circuit. The current flowing thru the wire will cause a DC voltage to be created because the wire has a small amount of resistance to current flow, about 16.9 ohms per 1000 feet for 22 gauge copper wire. If the resistance and current are known, the voltage can be determined by the voltage, current, and resistance relationship established by Ohm's Law .

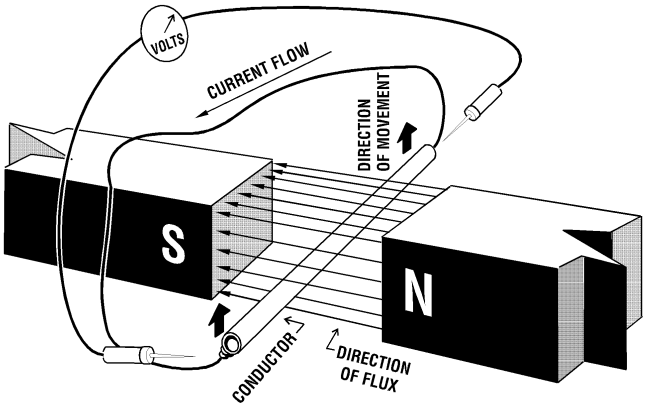
Ohm's Law for DC current

voltage = current x resistance

$E = I \times R$

CURRENT AND VOLTAGE GENERATION THEORY III

VOLTAGE MEASUREMENT



09-94-10

NOTES